George S. Clarke,

His Excellency the Hon'ble (Brevet) Colonel Sir GEORGE SYDENHAM CLARKE, R.E., G.C.M.G., G.C.I.E., F.R.S.

Governor of Bombay and President of the Congress.

TRANSACTIONS

OF THE

Bombay Medical Congress,

1909.

Edited by

LIEUT.-COLONEL WILLIAM ERNEST JENNINGS, M.D., D.P.H., I.M.S.

GENERAL SECRETARY OF THE CONGRESS; FELLOW OF THE ROYAL INSTITUTE OF PUBLIC HEALTH; HONORARY ASSOCIATE IN THE ORDER OF THE HOSPITAL OF ST. JOHN OF JERUSALEM; ASSOCIATE EDITOR OF THE "INDIAN MEDICAL GAZETTE"; AUTHOR OF A MANUAL OF PLAGUE, ETC.

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EDITOR'S PREFACE.

The idea of holding a Medical Congress in Bombay upon Tropical Diseases originated with His Excellency the Hon'ble Sir George Sydenham Clarke, Governor of Bombay, and no time could have been more opportune for the purpose than that which he selected. The first Indian Congress held in Calcutta years ago provided an incentive for earnest and vigorous research throughout India which was powerfully stimulated by the great pandemic of Plague which appeared shortly after and has not yet disappeared. The gradually accumulating fruits of this research, in varying degrees of maturity, have been awaiting garnering and sifting, processes which can only be satisfactorily effected by minute comparisons, the careful interchange of independent views and the modifying influence upon too rabid enthusiasm of a stern application of the principles of inductive and deductive logic. The necessity for some machine for combining these forces has been obviously becoming increasingly apparent year by year for several years past, and experience has shown that the only machine capable of producing the desired effect is a Congress of serious searchers after the same truths in different and widely scattered parts of the world. Contributions and delegates were therefore invited from Great Britain, the Continent of Europe, America, the Philippine Islands, Malay, Sumatra, Japan and other parts; those known to be engaged upon any particular form of research upon Tropical Diseases being particularly invited to attend or send papers. The varied contributions forming the bulk of this report represent the result of those invitations, and no more valuable testimony as to the successful nature of the gathering could be adduced than that given by Professor Musgrave in his report to the Government of the Philippine Islands (*vide* Appendix II of these transactions) in the following words, *viz* :—" In scope, material presented, and in attendance this was surely the most successful Congress dealing entirely with the problems of tropical medicine which has ever been held."

It would be convenient here to enumerate briefly some of the principal lessons which have been gleaned from the deliberations, the reader being left to peruse at leisure the evidences and discussions which have led to these conclusions :—

Cholera.—The bulk of opinion, contrary to much prejudice which has arisen of late years, favoured the employment of opium in the first stage, either hypodermically, or by several small doses internally, the total quantity given being within the limits of a single lethal dose to obviate accumulation and subsequent absorption *en masse.* It was also practically agreed, with regard to saline injections in the second stage, that the intra-peritoneal method is superior in practice to either the intra-venous or sub-cutaneous, and that hypertonic salt solution should be employed so as to maintain a high percentage of salt in the blood and thus cause the osmotic current to carry fluid to the vessels rather than allow it to escape therefrom.

Coloured Underclothing in the Tropics.—The advantages of orange or red coloured material for the lining of helmets and protection of the spines of those exposed to the sun were urged, and Capt. Nicholls, Medical Corps, U. S. A., read a paper by Capt. Phalen of the same Corps detailing experiments now being carried out in the Philippine Islands relative to the effects of coloured underwear. The results of these as well as of similar trials in Calcutta referred to by Major Leonard Rogers should prove of great interest.

Calf Vaccine in the Tropics.—It was generally agreed that glycerine is the most suitable preservative because of its bactericidal properties, many speakers however favoured the employment of Canolin.

Oatmeal in Diabetes.—Professor Carl Von Noorden (Vienna), in demonstrating the value of an Oat meal dietary in certain cases of Diabetes Mellitus, suggested, as the most likely explanation of what appears to be an anomalous phenomenon, that, with the oat, small quantities of a substance are introduced, into the system, which acts by stimulating the internal secretion of the Pancreatic gland.

Appendicostomy.—The evidence in favour of this form of treatment which was brought forward indicated that it deserves more extended trial in cases of chronic and intractable ulceration of the colon.

Dysentery.—Contrary to pre-existing notions as to the ætiology of this affection all the evidence brought forward seemed to point to its spread by means of the convalescing human being acting as a "carrier," not necessarily in the technical acceptation of that term, but by the shedding of the virus from unhealed intestinal lessions which reaches the alimentary tracts of healthy persons in various ways. This knowledge will be of value in effecting efficient prophylaxis in prisons, asylums, schools and other institutions. With respect to treatment, evidence was adduced as to the value of vaccine therapy with vaccine prepared from Shiga's bacillus in acute dysentery, and of the same combined with mercury in chronic dysentery. Replying to a refcrence as to the expense of serum therapy by Capt. Forster, Dr. Van Loghem (Sumatra) stated that she-goats give, in a few weeks, sera against pseudo-dysentery bacilli with litre of 2,000 and more. Dr. Castellani (Ceylon) contributed a note referring to a poly-valent vaccine which he had prepared of Typhoid, Para-typhoid B, Dysentery of the Kruse-Shiga type and Dysentery of the Flexner type, the degree of immunization induced by which he found to be the same as that induced by using the vaccines separately.

Enteric Fever.—Much stress was laid on the subject of bacilli carriers and the part they play in acting as store-houses of the virus in nature and sources of infection. Proof was adduced as to their being recruited from two classes, *viz.*, (1) Those who, after an attack of Enteric Fever, continue to harbour infection and excrete it in their fæces and urine, and (2) those who have been in close contact with the disease, or have lived under conditions where infection was possible, and who harbour the virus without having actually passed through a recognisable attack. It was further pointed out that carriers might be classified as accute or chronic, the former harbouring infection for a few weeks only and the latter for months or years. Colonel Semple indicated, as desiderata, ready methods of detecting carriers and of rendering them innocuous, stating that the solution of these two problems would mark the next most important advance towards the prevention of Enteric Fever. Valuable evidence was also brought forward with respect to the value of anti-typhoid vaccination both as a preventive and as an agent for mitigating the severity of attacks.

Hill Diarrhœa.—In refutation of the now somewhat untenable mica theory of the causation of this condition, Dr. Newell offered the suggestion, supported by reasonable evidence, that it is due to the diminution of the atmospheric pressure causing a deprivation of blood in the internal organs (chiefly the liver and intestines) leading to diminished functional activity and an abnormally luxuriant growth of intestinal floræ. As the sudden rush of blood to the surface can be controlled by suitable clothing, it would appear that the most important prophylactic measure is the wearing of some non-conductable material next to the skin in addition to the extra outside clothing usually worn.

Tropical Diarrhœas.—It was pointed out that, in addition to bacteriological and other examinations of excreta for the differential diagnosis of these obscure complaints, valuable indications for treatment are often afforded by blood examinations for ascertaining not only the degree of any anæmia present but also the nature of the white cell contents *e g.*, increase of mono-nuclears indicates cancer or protozoa ; of eosinophiles, hook worms ; leucocytosis or increase of poly-nuclears, the presence of hepatic suppuration or amœbic infection, &c., &c. In emphasising the importance of a blood examination in every case Capt. Macy, Medcial Corps, U. S. A., suggested, also, the making of agglutination tests, and the centrifugalization of the serum (as in making opsonic tests) for estimating the gravity of the case by noting the absence or otherwise of lipæmia during the alkaline tide of digestion. It is evident that such routine examinations might also reveal the existance of concomitant conditions otherwise overlooked.

Maternal and Infantile Mortality in India.—In bringing forward statistics bearing upon the enormous and preventable loss of life among infants and parturient females, Lieut.-Colonel Collie, I. M. S., advocated a more active policy than at present obtains for providing the women of India with skilled nursing, indicating lines upon which success has been achieved in other countries.

Malaria.—The result of a lengthy and somewhat spirited discussion on Malaria prevention was the general impression that efforts in this direction should follow the lines laid down by Professor Ross, *viz.*, (1) Mosquito-reduction in cities, towns, large stations and other densely populated places ; (2) the prophylactic administration of quinine in villages, rural areas and districts with scattered populations ; and (3) a combination of (1) and (2) under suitable conditions, or in the presence of severe malaria.

Professor Ross laid great stress on the necessity for measuring malaria in districts, and in his paper appear schemes for arriving at a useful estimate of the incidence by careful study of such statistics as might be available, and the direct examination of children, in any given locality. An important addition to our knowledge regarding the epidemiology of malarial fever was afforded by the evidence of Captain Christophers and Dr. Bentley who exhaustively proved that whole communities might become reservoirs of residual infection and thus involve neighbouring districts in epidemic malaria or, on migration of their members, diffuse infection far and wide. The important bearing of this human factor cannot be over-estimated in dealing with the recruitment and congregating together of large bodies of workers necessitated by Railway extension and the rapid growth of industry throughout the country.

Black-water Fever.—All evidence brought forward as to the ætiology of this disease pointed to its undoubted malarial origin; the malignant tertian parasite being the offender. Opinions were divided as to the determining factor, which, it was generally agreed, was neither quinine nor anything toxic in nature. Capt. Christophers and Dr. Bentley offered as an hypothesis that it might be an auto-lysin developed in consequence of the destruction of the red cells by a process described by them as Erythro-katalysis as distinct from the action exerted by parasites of the other species.

Plague.—With regard to the ætiology of plague, the following conclusions, enunciated by Major Lamb, I.M.S., as the results of the most recent researches of the Indian Plague Commission, were accepted, the report of experiments made by Professor Kitasato in Japan being fully confirmatory, *viz*:—

(1) Bubonic Plague in man is entirely dependent on the disease in the rat.

(2) The infection is conveyed from rat to rat and from rat to man solely by means of the rat flea.

(3) A case of bubonic plague in man is not in itself infectious.

(4) Insanitary conditions have no relation to the occurrence of plague, except in so far as they favour infestation by rats.

(5) Plague is usually conveyed from place to place by imported rat fleas, which are carried by people on their persons or in their baggage. The human agent not frequently himself escapes infection.

These conclusions led naturally to many measures being recommended for the extermination of rats and fleas in localities, and for prevention of their importation from infected to healthy places.

The practical difficulties, however, of applying such measures, and the futility of expecting any degree of success in the conditions which now obtain in India, drew forth from "field" workers, as contrasted with those who base their recommendations on bacteriological discoveries, some strong expressions of opinion against the idea of suggesting that such latter recommendations should entirely supplant measures, such, *e.g*, as evacuation, which had been proved to be of value in dealing with past outbreaks. There was no dissent as to the part inoculation should take in plague prophylaxis; and, with respect to treatment, evidence was adduced by Dr. Choksey to demonstrate that encouraging results had so far attended serum-therapeutical experiments.

Leishman Donovan Body Invasion.—In dealing with the subject of Kala Azar in Madras, Major Donovan emphasized the difficulties of clinical diagnosis, and gave it as his opinion that the risk of splenic puncture contra indicated its employment for diagnostic purposes. He pointed out, however, that, in 93·22 per cent. of his cases, the parasite was found in the polymorphonuclears or mononuclears of the peripheral blood, urging that the secret of success lay in the method of making the blood smears. A finger of the patient should be washed and dried and then compressed below the pulp for half a minute and pricked by a new pin, a drop about the size of a pin head should then be taken from the exuding blood on to a slide near its end, and a smear made by another slide passed slant-wise over it, the main object being to have the smear in a straight edge at the finish. In this edge, he states, everything of importance is found. As regards the apparent similarity between the parasite itself and that of oriental sore, Dr. R. Row of Bombay produced valuable evidence in demonstration of the two being distinct organisms when examined in cultures. In congratulating Dr. Row on his having successfully cultivated the latter, Major Leonard Rogers, I.M.S., said that the absolutely different distribution of the two diseases in India had always made him regard them as likely to prove quite distinct.

Sleeping Sickness.—After an exhaustive consideration of the characters of the Tsetse fly and the infective organisms (trypanosomes) of which it forms an intermediate host, Capt. Greig, I.M.S., indicated the best lines for prophylaxis to lie in (*a*) *operations directed against the fly*, *e.g.*, clearing of undergrowth wherever human beings are brought together in numbers ; destruction of the main food supply of the fly, *viz.*, blood of crocodiles, by destroying those animals ; and the destruction of the fly by such agents as animals which will prey on it (certain kinds of fish) or plants whose odours would be obnoxious ; (*b*) *Operations directed against the parasite harboured by the fly*, *e.g.*, by drugs such as arsenic, atoxyl (a combination of arsenic and an aniline preparation), antimony compounds and aniline dyes. In addition, he considered that isolation camps should be established in fly-free areas for the segregation of infected persons, and that measures should be employed for the detection of all harbourers of the trypanosome and the prevention of their movement into clean fly-areas. Such detection, he pointed out, is easily effected by microscopical examination of gland juice, obtained by puncturing a superficial gland in the posterior cervical triangle with a hypodermic syringe, in which actively motile trypanosomes can readily be detected under a low power, 150 to 200 diameters. Mr. F. M. Howlett advocated research by Indian Veterinary Surgeons upon the causes of surra on the lines of Capt. Grey's paper, pointing out that it had been found for certain that the genus Hæmatopota (Tabanidæ) was a transmitter of surra. He suspected that other biting flies might also carry infection, but investigation work had not yet been started.

Ticks and Biting and Non-biting Flies.—Capt. Carter, I.M.S., and Dr. J. T. C. Nash contributed important papers on the roles played by biting and non-biting flies, respectively, in the transmission of various diseases to mammalia. As regards the former Capt. Carter dwelt at length on the effect which the parasites he described are exerting with respect to the economics of the present and succeeding generations, if only because of fly-borne scourges among cattle and domestic animals checking the opening up of vast fertile tracts in Africa. As to the latter Dr. Nash adduced abundant evidence to prove how grossly the apparently harmless house-fly can pollute food by depositing putrefactive bacteria thereon giving rise to chemical changes which might easily exert toxic effects upon the consumers. His conclusions lend important confirmation to the growing conviction that the association between seasonal diarrhœa in India and elsewhere and the prevalence of flies is more than merely coincidental. Mr. F. M. Howlett minutely described different species of sand flies and their habits, and urged that the fact that the period of their maximum abundance coincides in many districts with the most unhealthy season of the year, when obscure short period fevers are often prevalent, especially in such localities as are particularly favoured by the flies, seems to provide evidence for a *prima facie* case sufficiently strong to warrant further investigation.

Snake Venoms.—The bulk of the evidence brought forward pointed, undoubtedly, to the true solution of the problem of neutralizing the effects of these venoms in the system, being the employment of anti-sera. So far the greatest drawback in this direction, apart from the difficulties of preservation, has been that the marked specificity of the poisons has precluded the production of a sufficiently poly-valent serum ; that prepared by Major Lamb, and issued from Kasauli, being only antidotal to two poisonous species. Attention, however, was drawn to the fact that we have a powerful antidotal weapon in the shape of the local application of crystals of permanganate of potash as advocated by Sir Lauder Brunton and others. Though this agent is capable of neutralizing the poisons of all snakes, its employment is only of efficacy before the onset of constitutional symptoms, and, for its successful application, it would appear that a very thorough excavation at the site of the wound is essential, simple scarification being generally useless. The old traditional measures, *viz.*, suction and ligature would appear to possess little, if any, intrinsic value ; their moral effect, however, being great, especially in cases suffering from fright after bites of non-poisonous snakes, they should not be discouraged. Artificial respiration in colubrine cases, and the employment of calcium chloride and adrenaline in viperine ones, were shown to be useful auxiliary measures.

Streptothricosis.—Major Hooton, I.M.S., and Dr. Powell described some cases of Actinomycosis ; the former drawing attention to some clinical points of distinction between the condition and that known as Mycetoma for which it might be mistaken, *e.g.*, the latter rarely attacks any part but the feet and hands ; it is unaffected by Iodide of Potassium, while Actinomycosis keenly reacts thereto ; it never becomes generalized though it occasionally involves lymphatic glands, while Actinomycosis frequently forms metastatic deposits and never involves

lymphatic glands. With respect to pathological distinction, Professors Musgrave and Clegg, in their exhaustive monograph (read by Professor Musgrave), sought to fix the ætiology and classification of mycetoma, and their conclusions are quoted as follows :—

"There is, in human pathology, a very important group of branching, filamentous micro-organisms which logically belong to a single genus. The generic name is variously given as *Streptothrix*, *Actinomyces* or *Nocardia*; the last of these names is probably scientifically the most correct, but because of the present botanical confusion and uncertainty the first is here employed, because of its more general acceptance.

The following species to judge from our work and from a study of the literature are the most important and may be recognized as established. There are probably a number of others, but the descriptions of many of them are too imperfect to allow of their recognition :—

S. actinomyces Bostroem, 1890.
S. actinomyces Wolff & Israel, 1891 and Wright, 1905.
S. nocardii.
S. eppingeri.
S. maduræ Vincent.
S. capræ Silberschmidt.

The disease caused by infection with these parasites is properly named streptothricosis, with actinomycosis and nocardiosis as synonyms. Other names, such as lumpy-jaw, madura foot, mycetoma, etc., should be considered more as describing anatomic location rather than as designations relating to any special or specific cause of infection. Mycetoma might well be taken as the correct name for the group of infections if a strict interpretation of rules of nomenclature is followed, but usage renders it perhaps more desirable to retain the name as representing *Streptothricosis pedis*. If mycetoma is to be considered in any more comprehensive light than this, it should become another synonym for streptothricosis. It should not be considered a disease caused by organisms other than *Streptothricæ*."

Lathyrism.—Lieut.-Colonel Buchanan produced undoubted evidence to prove that this condition is caused by the ingestion of the grain variously known in India as lathyrus, lakh, lakhori, teora, &c., it being essential that the grain be consumed in large quantities, and for a considerable time, before the disease appears. Modifying influences are the growth of the grain in rice areas, its employment as dhal (when it is boiled), and decortication before use, in all of which circumstances it rarely causes lathyrism.

Beri-beri and Epidemic Dropsy.—The evidence regarding the ætiology of Beri-beri brought forward by Dr. Leonard Braddon leaves practically no room whatever for doubt that the disease is due to an intoxication caused by a specific poison contained in rice when stale, *i.e.*, after long exposure subsequent to decortication. Professor Musgrave, in his report to the Government of the Phillipine Islands (*q. v.*), states that he has, since the Congress, seen the advance sheets of a report from Dr. Frazer of the Kuala Lumpar Laboratory which contains the strongest evidence yet brought forward in support of this hypothesis. Although the theory is not a new one, it has been a much disputed one, possibly because only comparatively recently have we come to recognize a pathological distinction between Beri-beri and other, clincally, somewhat similar affections, *e.g.* epidemic dropsy and the peripheral neuritis following the excessive use of alcohol (as described by Lt.-Col. Mc Gill, R.A.M.C.) in which rice could generally be eliminated as a possible ætiological factor. Now, thanks to the evidence of Col. Kenneth Macleod, I.M.S., Lt.-Col. McGill, R.A.M.C., Dr. Benjamin and others, that we are in a position to recognize Beri-beri as a distinct affection, prophylaxis, in the light of evidence as to its causation, should be a simple matter, the only measure necessary being the avoidance of *stale uncured rice*. Dr. Braddon states that when cured rice cannot be procured, and yet rice must be used, Beri-beri may be avoided if only a moderate amount be given for a daily ration. and this be freely diluted with proteid and fatty food. "Curing" consists in soaking fresh raw grain for one or more days in water (often till germination commences), then rapidly steaming till the husks burst, then partially drying, and finally milling lightly to remove the husks. The result is a yellowish, semi-translucent toughened and perhaps partly malted grain on which the perisperm and the surface seed cells are preserved intact.

Leprosy.—After enumerating the various media in which he had failed to obtain Hansen's bacillus in pure culture, Professor Shiga announced that his experiments with lecithin had so far been encouraging and led him to expect favourable results in the future. Professor Unna described methods of differential staining of leprous tissues for demonstrating the effects of treatment, &c., by comparing the numbers of dead and living organisms, each class being recognisable according to different staining reactions. Professor Deycke Pasha contributed a paper describing the rationale of his Benzoyl Nastine treatment of leprosy, the former agent—in the form of benzoyl chloride—having the effect of removing fat from the lepra bacillus, and the latter—the active principle in cultures of Streptothrix leproides—acting as a carrier, without which the former would, through its activity, enter into combination with other organic substances in the body, and never reach the lepra bacillus. The evidence in support of the treatment from the Persian Gulf and different parts of India was sufficiently abundant to justify very much more extended trial of the method than has hitherto been employed.

Sanitation in India.—The papers and discussions in this department dealt principally with water-supplies, the more extended application of modern sanitary methods to India and questions of sewage disposal. With regard to the first, among others. papers were contributed by Drs. Thresh, Matthew, Dadachanji, Nesfield and Katrak. Valuable suggestions will be found dealing with sources, methods of filtering, purifying agents, standards of purity, storage, service, protection from contamination on ships, &c., &c. As to the second, measures were indicated as necessary for improving the Sanitary condition of Bombay, for the introduction of a Sanitary policy in connection with Hill stations, and, generally, for the establishment of an improved sanitary organization throughout India. With regard to sewage and refuse disposal, contributions were read from Messrs. Fowler, Dibdin, Maxwell, Scott-Moncrieff, Drs. Cursetji and Master and others, in the course of which the relative merits of different systems, *e.g.*, septic tanks, discharge into the sea or tidal estuaries, slate beds, hopper barges, incinerators, reclamation, &c., &c., were fully gone into. Although, in the opinion of some, septic tanks had not realized the expectations originally entertained, the more general impression seemed to point to their being destined to take a very prominent part in sewage disposal in the future. Dr. Newell suggested, in controversion of the prevailing idea that purification depends on the action of aerobic and anaerobic organisms, that facultative microbes also take a part in the process, and considered that the best results would be obtained by having (1) a grit chamber for separation of inorganic debris; (2) a septic tank for anaerobic action to prepare the sewage for such subsequent action; (3) upward filtration through contact beds for action of facultative organisms; (4) downward filtration through contact beds for aerobic action; and (5) passage upon percolating filters or, instead, land filtration. Mr. G. B. Williams, Sanitary Engineer, Bengal, replying to Mr. Fowler's paper on sewage discharge into tidal estuaries, referred to the possible pollution of shell-fish by the process being a drawback. Dr. Turner referred to the trial about to be given by the Corporation of Bombay for burning of rubbish by the Horsefall Incinerator, an appliance which is working successfully in other tropical cities; he gave it as his opinion that on the whole a good system of incinerators would be more economical than the procedure now adopted in Bombay. Dr. Nair pointed out that the calorific power of dry rubbish in India, being inferior to that in England, made the relative economic values of the process different in the two countries. Drs. Cursetji and Master read a paper on the chief defects in the present modes of disposal of sewage and town refuse in Bombay, suggesting possible remedies.

Naval and Marine Hygiene.—Dr. F. G. Clemow, British Delegate on the International Board of Health at Constantinople, contributed a paper on the *Haj Pilgrimage from India and the International Sanitary Conventions.* While he bore flattering testimony to the manner in which the Government of India carried out their obligations in this connection, he suggested reimposition of the period of quarantine before departure of pilgrims from India which had recently been abolished. In view of the measures that are taken in Bombay, the length of the voyage, the preparations at Perim and the compulsory quarantine at Camaran, Col. Crimmin and Dr. Blackmore considered that Dr. Clemow had by no means made out a sufficiently strong case to justify this suggestion; the latter adding that the Turkish authorities might well be asked to take steps within their own borders to obviate breeding places for cholera, small-pox, etc., the insanitary condition of Mecca and Jedda being notorious, and it being well known, as pointed out by Col. Crimmin in a separate paper, that much of the small-pox in India is started by returning pilgrims from the Haj.

Fleet Surgeon Clayton, R.N., contributed a paper on the *Incidence of Tropical Diseases among Naval Men in Warm Climates*, illustrating the influence of the sailor's environment upon causation or prevention of tropical diseases, considering each with respect to known methods of convection ; *e.g.*, as he is largely protected from the attacks of mosquitoes and other biting flies, is usually provided with an absolutely pure water-supply, has his food well supervised, and prepared in circumstances which militate against specific contamination, the sailor remains practically immune to affections common among those not so protected, such as Malaria, Plague, Yellow Fever, Kala Azar, Trypanosomiasis, Typhoid Fever, Dysentery, &c., &c. The disposal of his excreta, moreover, being simple and perfect, and boardship conditions in the tropics entailing long exposure in the open air, his resistance is greater than that of shore dwellers. On the other hand, he is subject to a far greater degree of overcrowding and more trying temperature conditions than those on shore, and his supply of fresh water for ablutionary purposes is distinctly limited ; these latter conditions naturally predispose him to heat stroke, skin affections, gastric irritability with pyrexia, &c., and Dr. Clayton suggests suitable means of prophylaxis. Dr. Blackmore read a paper on the *Carriage of Plague by Sea*, his main contention being that docks in infected countries should be kept free from rats (1) by using traps, (2) by employing the natural enemies of rats, *e.g.*, dogs, cats and ferrets, (3) by poisoning, (4) by introducing a fatal infectious disease among them, and (5) by fumigation with poisonous or irrespirable gases. Several papers were contributed relative to the shore and boardship environment of mariners, in the course of which Fleet Surgeon Clayton referred to the necessity for improved ventilation on British men-of-war, adding that a supply fan connected with the hollow masts seemed to be the only solution. He considered the prevalence of tonsilitis as an index of overcrowding. With regard to water on vessels he urged that the drinking supply should be distilled and distributed in a distinct set of pipes from those used for shore water. Dr. Bawa (Colombo) suggested improved measures for the prevention of the spread of infectious disease on boardships ; Dr. Shroff (Bombay) referred to the existing regulations for the prevention of the spread of plague by sea, proposing modifications, and Capt. Jones (Med. Dept., U. S. A.) read a paper pointing out methods for improving the sanitary condition of the Army Transports of the United States.

Tropical Surgery.—Most of the papers in this Section dealt with Ophthalmic Surgery and operations for Urinary Calculi. Perhaps one of the most practical lessons gleaned from the deliberations on the former was that obviously indicated by Major Kilkelly's observation while inspecting mofussil dispensaries, *viz.*, that the Atropine bottles were mostly nearly empty while the Eserine ones were mostly unopened. It is hoped that his suggestions in this connection will bear fruit, for there can be no doubt that many cases of glaucoma have in the past escaped detection and proper treatment. With regard to cataract extirpation, an animated (if somewhat one-sided) discussion took place on the relative merits of the intra and extra-capsular methods. The exponents of the former or Smith's method, including Major Smith, I.M.S., himself, brought forward facts and statistics in its favour which could leave no doubt as to its greater advantages over the latter, all things being equal. The "equality of all things," however, is at present the moot point, for, to refer to only one weak spot in the method, freely admitted by Smith and his followers, the operator is very largely dependent for his success on his assistant, which is not the case in the extra-capsular operation. It will not, therefore, be a matter of great surprise if the latter operation continues to hold its own indefinitely. Again a somewhat pertinent suggestion by Major V. B. Bennett, I.M.S., offers food for investigation and reflection. He considers, for reasons given, that the class of cataract met with in the districts in which the operation has been so successful might render the cases more amenable to intra-capsular extraction than elsewhere. Time and growing experience will clear up these and other points. In the meanwhile nothing but unbounded admiration can be felt towards the brilliant surgeon who has perfected the method, who numbers his operations by tens of thousands where many in other countries who have reached fame are proud of their thousands, and to whom operators now come from all parts of the world to be instructed. Among the papers on Ophthalmic Surgery were one on Trachoma, Panus and Corneal Ulcer by Major Smith, several connected with Smith's cataract operation by Captains McKechnie, Oxley, Lister and Gidney, Drs. Jamison and Bhandari and Hospital Assistant Mathradas, and one on Incision of the Eye by Captain McKechnie. Among those dealing with *Urinary Calculi*, Surgeon-General Stevenson, I.M.S., read a paper upon Perineal Litholapaxy in children, as originated and practised by Colonel Keith, I.M.S., one of his predecessors in the district (Hyderabad, Sindh) in which he acquired the bulk of his great experience in Urethral Surgery. In this, as well as in a paper on the same subject by Major Evans, I.M.S.,

valuable hints will be found regarding the technique of so valuable a procedure in cases inoperable per urethram without incision. Major Evans bases his suggestions upon a series of observations made upon the cadaver for ascertaining important land-marks and their mutual topical relationship in different attitudes of the body. In a note upon Litholapaxy in India, Colonel Keegan, I.M.S. (retired), urged that, in the case of boys, short canulæ should be employed, and smaller exhausting bags than those used for men, adding that canulæ should have steel stylets. Lt.-Col. Durrell Pank contributed a paper on the same subject, giving the results of his experience of some hundreds of cases. Major Smith, I.M.S., contributed papers on Rhinoplasty, Excision of the Upper Jaw and the Gasserian Ganglion and the surgical treatment of diseased lymphatic glands, describing modifications on old methods, introduced by him, and practised with success. Papers upon Elephantiasis of the Scrotum, Epipoplexy, Spinal Analgesia and the treatment of Hydrocele, Ascites and Elephantiasis by artificial lymphatics were contributed by Major Gabbett, I.M.S., Captain Novis, I.M.S., Captain Chalmers, I.M.S., and Major Ashton Street, I.M.S., respectively. Major V. B. Bennett introduced a discussion upon Abdominal Surgery with special reference to Hernia and, among others, Dr. Wanless (Miraj) read a paper on Gastro-Enterostomy for Gastric and Duodenal Ulceration, and Dr. Ernest Neve (Kashmir) one on Epithelioma in Kashmir, one cause of which he has demonstrated to be the use of the kangri or portable fire basket.

Section VI comprised, generally, an exhibition of medical, surgical, sanitary, building, ventilating, disinfecting and fumigating appliances, &c.; drugs, foods and toilet requisites; hospital and operation room furniture; model buildings; models of improved areas in Bombay; scientific instruments; medical and scientific publications, &c., &c. There was also a museum of pathological specimens, and series of demonstrations including microscopical and lantern slides of interesting specimens, diagrams, charts, microscopical specimens, &c., &c. On the second day a Conversazione was held in the Exhibition grounds between 7-30 and 11-30 P.M., to which all members were invited. After the Sessions the Exhibition, bereft of its purely technical characters, was popularized by the addition of carefully selected side-entertainments and thrown open to the general public for some weeks.

The proceeds (*vide* Financial Statement, Appendix III) were converted into the nucleus of a Fund to be known as the "Miss Clarke Memorial Nursing Fund (founded by the Bombay Medical Congress)" which will be held in Trust by the Bombay Branch of the Countess of Dufferin's Fund, the revenue being administered by them for furthering the aims of nursing in the Bombay Presidency proper.

Bombay Medical Congress, 1909.

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Programme of Sessions.

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BY

H. E. THE GOVERNOR OF BOMBAY, *President of the Congress, at 11 a.m., 22nd February 1909.*

CONVOCATION HALL, BOMBAY UNIVERSITY.

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Bombay University Library.

FIRST DAY—22ND FEBRUARY 1909.

Cholera, &c.

PRESIDENTIAL ADDRESS

By Surgeon-General A. T. SLOGGETT, C.M.G., R.A.M.C., President of the Section.

Treatment of Cholera, by Major LEONARD ROGERS, M.D., I.M.S.
Treatment of Cholera, by Khan Bahadur N. H. CHOKSY, M.D.
Value of Coloured Underclothing for American Soldiers in the Phillipines by Capt. PHALEN and First Lieut. H. J. NICHOLS, M.D., U. S. Army.
Preparation, Storing and Distribution of Calf Vaccine, by Capt. F. H. G. HUTCHINSON, M.B., I.M.S.
Treatment, of Diabetes Mellitus by Oatmeal, by Professor CARL VON NOORDEN (Wien).

SECOND DAY—23RD FEBRUARY 1909.

Dysentery, &c.

Appendicostomy for Intractable Ulceration of Colon, by Capt. E. F. GORDON TUCKER, F.R.C.S., I.M.S.
Chronic Gastric and Duodenal Ulcer, by W. J. WANLESS, M.D.
Prevention and Treatment of Dysentery in Jails, by Lt.-Col. W. J. BUCHANAN, B.A., M.D., D.P.H., I.M.S.
Dysentery in Jails, by Capt. W. C. H. FORSTER, M.D., I.M.S.

THIRD DAY—24TH FEBRUARY 1909.

Enteric Fever, &c.

Ætiology, Diagnosis, Prophylaxis of Enteric Fever in India, by Lt.-Col. SEMPLE, M.D., D.P.H., R.A.M.C.
Typhoid Fever in Travancore, by J. DAVIDSON, M.D.
Hill Diarrhœa, by A. G. NEWELL, M.D., C.M. L.M., D.P.H.
Maternal Death Rate, by Lt.-Col. M. A. T. COLLIE, M.B., I.M.S.

SECTION II.

Convocation Hall.

FIRST DAY—22ND FEBRUARY 1909.

Malaria, &c.

PRESIDENTIAL ADDRESS

By Surgeon-General H. HAMILTON. C.B., M.D., V.H.S., I.M.S., President of the Section.

Practice of Malaria Prevention, by Professor RONALD ROSS, Nobel Laureate, F.R.C.S., D.SC. LL.D. F.R.S., C.B., Major I.M.S. (Retired).
The Intimate Pathology of Malaria in relation to Blackwater Fever by Captain S. R. CHRISTOPHERS, M.B., I.M.S., and C. A. BENTLEY, M.D., D.P.H.
The Human Factor, an extension of our knowledge *re* Epidemiology of Enteric Fever, by Capt. S. R. CHRISTOPHERS, M.B., I.M.S., and C. A. BENTLEY, M.D., D.P.H.
Malaria in Mian Mir, by Major S. P. JAMES, M.D., D.P.H., I.M.S.

SECOND DAY—23RD FEBRUARY 1909.

Plague, &c.

Fleas and Plague in Japan, by Professor KITASATO.
Ætiology and Epidemiology of Plague, by Major GEORGE LAMB, M.D., I.M.S.
Clinical Significance of Septicæmia in Plague, by Khan Bahadur N. H. CHOKSY, M.D.
Prophylaxis of Plague, by Capt. W. GLEN LISTON, M.D., I.M.S.
Serum Therapy of Plague, by Khan Bahadur N. H. CHOKSY, M.D.
Symptomatic Treatment of Plague, by Khan Bahadur N. H. CHOKSY, M.D.
Anti-Plague Inoculation at Bangalore, by Major R. F. STANDAGE, M.R.C.P., M.R.C.S., I.M.S.
Recrudescence of Plague, by Major S. BROWNING SMITH, M.R.C.S. L.R.C.P., I.M.S.
The Races of Indian Rats by Capt. R. E. LLOYD, M.B., D.Sc., I.M.S.
Cats as Plague Preventers, by Lt.-Col. A. BUCHANAN, I.M.S.

THIRD DAY—24TH FEBRUARY 1909.

Leishman-Donovan Bodies, &c.

Kala Azar in Madras, by Major C. DONOVAN, I.M.S.
Fevers in the Phillipines, by Capt. WHITMORE, U. S. Army.
Relapsing Fever, by Khan Bahadur N. H. CHOKSY, M.D.
Pathogenic Spirochætosis in Mammalia, by Capt. R. M. CARTER, M.R.C.S., L.R.C.P. I.M.S.
Observations on the Development of Flagellated Organisms from the Parasite of Oriental Sore, by R. ROW, M.D. (London), D.SC. (London)

SECTION III.

Bombay University Library.

FIRST DAY—22ND FEBRUARY 1909.

Animal Parasites, &c.

PRESIDENTIAL ADDRESS

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Tsetse Flies, by Capt. E. D. W. GREIG, M.D., B.SC., F.R.C.S., I.M.S.
The Dissemination of Disease by Ticks and Diptera, by Capt. R. M. CARTER, M.R.C.S., L.R.C.P. D.T.M., I.M.S.
The Rôle of Non biting Flies as Carriers of Disease, by J. T. C. NASH, M.D., D.P.H.
Indian Sand-flies, by F. M. HOWLETT, Second Imperial Entomologist.

SECOND DAY—23RD FEBRUARY 1909.

Snake Venoms, &c.

Snake Venom and Means of Preventing, by Sir LAUDER BRUNTON, Bart., M.D., D.SC, LL.D. (Edin. and Aberd.), M.D. (Hon. Dub.), F.R.C.P., F.R.S
Snake Venoms and Snake-Bite, by Major GEORGE LAMB, M.D., I.M.S.
Snake-Bite and Treatment of Snake Poisoning, by Major F. WALL, I.M.S.
Actinomycosis, by Major A. HOOTON, M.R.C.S., L.R.C.P., I.M.S.
Actinomycosis, by A. POWELL, B.A., M.B., M.Ch.
Lathyrism, by Lt. Col. A. BUCHANAN I.M.S.
Piroplasmosis, by Capt. F. H. G. HUTCHINSON, M.B., D.P.H., D.T.M. & S., I.M.S. and Capt. F. N. WHITE, M.D. (London), I.M.S.

THIRD DAY—24TH FEBRUARY 1909.

Beri-Beri, &c.

Beri-beri, its Causes, &c., by W. L. BRADDON, M.B., B.S., F.R.C.S.
Beri-Beri and Epidemic Dropsy, by Col. MCLEOD, I.M.S. (Retired).
Leprosy, by Professor SHIGA.
Two Stains to differentiate Living and Dead Bacilli of Leprosy in Tissue, by Professor P. G. UNNA, M.D.
Nastin Treatment of Leprosy, by Capt. T. S. BEAUCHAMP WILLIAMS, M.B.
Nastin Treatment of Leprosy, by Major T. JACKSON, M.B., B.Ch., B.A.O., I.M.S.
Nastin Treatment of Leprosy by Capt. F. Smith, M.D., D.P.H., I.M.S., and Capt. E. BISSETT, M.B., I.M.S.
Nastin Treatment of Leprosy, by Dr. RODRIGUES.
Treatment of Leprosy by X Rays, by D. A. TURKHUD, M.B., C.M.
Beri-beri, by S. M. VARIS, M.D.

FOURTH DAY—25TH FEBRUARY, 1909.

Mycetoma, &c.

Streptothricosis with special reference to Ætiology of Mycetoma, by Professor W. E. MUSGRAVE, M.D.
Mycetoma, by N. F. SURVEYOR, M.A., B.SC., M.D., M R.C.P, D.P.H.
Distribution, Pathology and Bacteriology of Mycetoma, by J. E. BOCARRO, L.M.S.

SECTION IV.

Tent, Exhibition Grounds.

FIRST DAY—22ND FEBRUARY, 1909.

PRESIDENTIAL ADDRESS.

By Lt.-Col. J. CRIMMIN, V.C., C.I.E., D P.H., I.M.S.

Water-supplies and Measures for ensuring Purity, by J. C. THRESH, M.D., D.SC.
The Storage of Drinking Water on Board of Ships, by Lt.-Col. J. Crimmin, V.C., C.I.E., D.P.H., I.M.S.
Water-supplies and Measures for ensuring Purity, by K. E. DADACHANJI, L.M.S.
Purity of Water, by K. E. DADACHANJI, L.M.S.
Standard of Water Purity for India, by N. N. KATRAK, L.M.S.
Sanitation in the Hills (India), by Lt.-Col. W. BEEVOR, M.B., M R.C.S., R.A.M.C.
Unhygienic Bombay, by J. J. CURSETJEE, M.D., and D. B. MASTER.

SECOND DAY—23RD FEBRUARY, 1909.

India, the Haj, and the International Sanitary Conventions, by F. G. CLEMOW, M.D., D.P.H.
Small-pox on Pilgrim Ships, by Lt.-Col. J. CRIMMIN, V.C., C.I.E., D.P.H., I.M.S.
The Incidence of Tropical Diseases among Naval Men serving in Hot Countries, by Fleet-Surgeon F. H. A. CLAYTON, M.D., M.R.C.P., R.N.
The Carriage of Plague by Sea, by G. J. BLACKMORE, M. D.
Sea-borne Plague Regulations and Environment of Sailors in the Tropics, by B. S. SHROFF, L.M.S.
Isolation of Infectious Disease on Boardship, by H. BAWA, F.R.C.S.E.

THIRD DAY—24TH FEBRUARY, 1909.

Disposal of Sewage and Town Refuse, by W. H. MAXWELL, A.M.I.C.E.
Observations on the Effects of Discharge of Septic Tank Sludge in a Tidal Estuary, by G. J. FOWLER D.SC., F.I.C.
Primary Treatment of Sewage, by W. J. DIBDIN, F.I.C., F.C.S.
Some Recent Aspects of the Sewage Problem, by W. D. SCOTT MONCRIEFF, Engineer.
Defects of Sewage Disposal, &c., in Bombay, by J. J. CURSETJEE and D. B. MASTER.
Disposal of Refuse on Hill Stations in India, by Lt.-Col. W. BEEVOR, M.B., M.R.C.S., R.A.M.C.

FOURTH DAY—25TH FEBRUARY, 1909.

Sanitation in India, by J. A. TURNER, M.B., D.P.H.
Disinfection of Native Habitations, by Major J. CORNWALL, M.A., M.D., D.P.H., I.M.S.
Disinfection of Indian Houses, by SORAB C. HORMUSJI, M.D. (Brux.), D.P.H. (Lon.), M.R.C.S., L.R.C.P. (Lon.).
Effects of Izal and Heat on Fleas, by P. S. RAMCHANDRIER, Sub-Assistant Surgeon.

SECTION V.

Bombay University Library.

FIRST DAY—22ND FEBRUARY, 1909.

PRESIDENTIAL ADDRESS.

By Surgeon General H. W. STEVENSON, I.M.S., Sectional President.

Treatment of Trachoma Panus and Corneal Ulcer, by Capt. HENRY SMITH, M.D., I.M.S.
Intra-Capsular Operation for Cataract, by Capt. H. A. J. GIDNEY, F.R.C.S., D.P.H., I.M.S.
After History of 100 cases of Vitreous Escape in Smith's Operation, by Capt. A. E. J. LISTER, M.B., F.R.C.S., I.M.S.
Notes and Observations on the Extraction of Cataract in the Lenticular Capsule, by Capt. W. E. MCKECHNIE, M.B., I.M.S.
Extraction of Cataract in the Capsule, by R. JAMISON, M.B., B.Ch. (R.U.I.), Belfast.
Glaucoma, by Major P. P. KILKELLY, M.B., I.M.S.
Cataract Extraction in Capsule, by Capt. J. C. S OXLEY, I.M.S.

SECOND DAY—23RD FEBRUARY, 1909.

After Treatment in Cataract Operations, by Senior Asstt. Surgeon KIDARNATH BHANDARI.
On Cataract Operations, by Hospital Assistant MATHRADAS.
On Cataract Extraction, by Capt. A. E. J. LISTER, M.B., F.R.C.S., I.M.S.
On Incision of the Eye for Cataract Extraction and Relief of Glaucoma, by Capt. W. E. MCKECHNIE, M.B., I.M.S.
Rhinoplasty, by Major H. SMITH, M.D., I.M.S.
Litholapaxy, by Surgeon-General H. W. STEVENSON, I.M.S.
Stone in the Bladder, by Lt.-Col. R. DURRELL PANK, L.R.C.P., L.R.C.S., I.M.S.
Litholapaxy in India, by Col. KEEGAN, F.R.C.S., I.M.S.

THIRD DAY—24TH FEBRUARY, 1909.

Elephantiasis of Scrotum (with Supplementary Notes), by Major P. C. GABBETT, M.R.C.S., L.R.C.P., I.M.S.
Treatment of Hydrocele, Ascites and Elephantiasis by Artificial Lymphatics, by Major ASHTON STREET, M.B., F.R.C.S., I.M.S.
Abdominal Surgery with special reference to Hernia, by Major VIVIAN BOASE BENNETT, M.B., F.R.C.S., I.M.S.
Epipoplexy, by Capt. T. S. NOVIS, I.M.S.
Epithelioma in Kashmir, by E. F. NEVE, M.D., F.R.C.S.E.
Excision of the Upper Jaw, by Major HENRY SMITH, M.D., I.M.S.
Excision of the Gasserian Ganglion, by Major HENRY SMITH, M.D., I.M.S.
Surgical Treatment of Diseased Lymphatic Glands, by Major HENRY SMITH, M.D., I.M.S.
Spinal Analgesia, by Capt. A. CHALMERS, M.B., I.M.S.

SECTION VI.

The Oval.

This Section comprised generally an EXHIBITION of medical, surgical, sanitary, building, ventilating, disinfecting and fumigating appliances, &c.; drugs, foods, and toilet requisites; hospital and operation room furniture; model buildings; models of improved areas in Bombay; scientific instruments; medical and scientific publications, &c. &c.

A MUSEUM OF PATHOLOGICAL SPECIMENS, and series of DEMONSTRATIONS were held, including extraction of snake venoms; microscopical and lantern slides of interesting specimens; diagrams charts, macroscopical specimens, &c., &c.

On the Second Day there was a CONVERSAZIONE from 7 to 11·30 p.m., to which all members were invited. At the Conversazione a series of LANTERN SLIDE DEMONSTRATIONS was given, of which the following was the Programme:—

- Leprosy Treatment by Nastin.—By Capt. BEAUCHAMP WILLIAMS, I.M.S., Bushire.
- Cholera Epidemics.—By Major LEONARD ROGERS, I.M.S., Calcutta.
- Parasite of Delhi Boil.—By R. ROW, M.D. (LOND.), Bombay.
- Blood-sucking Insects.—By F. M. HOWLETT, 2nd Imperial Entomologist, Pusa.
- The Tsetse Fly.—By Capt. GREIG, I.M.S., Bombay.
- Snakes, Poisonous and Non-Poisonous.—By Major WALL, I.M.S., Almora.
- Fevers.—By Major LEONARD ROGERS, I.M.S., Calcutta.

TRANSACTIONS

OF THE

BOMBAY MEDICAL CONGRESS.

OPENING CEREMONY OF THE SESSIONS.

The opening ceremony of the sessions took place at 11 a m. on Monday, the 22nd February, in the Convocation Hall of the Bombay University which was filled almost to overflowing by members and invited guests. His Excellency Brevet-Colonel The Hon'ble Sir George Sydenham Clarke, G.C.M.G., G.C.I.E., F.R.S., R.E., Governor of Bombay and President of the Congress, and Miss Clarke were met at the main entrance by Surgeon-General Sir Gerald Bomford, Director-General of the Indian Medical Service; Surgeon-General H. W. Stevenson, Surgeon-General with the Government of Bombay; Surgeon-General P. H. Benson, Surgeon-General with the Government of Madras; Surgeon-General H. Hamilton, P.M.O., Rawal Pindi Division; Surgeon General A. T. Sloggett, P.M.O., Poona Division; Col. R. H. Forman, P.M.O., Bombay Brigade; and Lieut.-Col. W. E. Jennings, General Secretary of the Congress.

The party were then conducted to the dais by the General Secretary where His Excellency and Miss Clarke were received by the Hon'ble Sir John W. P. Muir Mackenzie, the Hon'ble Mr. J. L. Jenkins, the Hon'ble Sir Walter Hughes and the Vice-Presidents and members of the Central Committee. The proceedings were then opened by the following address by Surgeon-General H. W. Stevenson, I.M.S., President of the Central Committee.

Address by Surgeon-General H.W. Stevenson, I.M.S.

Your Excellency, Ladies and Gentlemen,—As President of the Central Committee of the Bombay Medical Congress the honour of opening these proceedings devolves upon me, and, with your Excellency's permission, I shall give a brief sketch of the progress of the undertaking since its inception up to the present time. The need for holding a Congress upon Tropical diseases has been becoming increasingly apparent for several years past, and we are deeply indebted to your Excellency for meeting the necessity by originating this one, and for the very encouraging stimulus afforded by your continued interest in our proceedings. As your Excellency will remember, the initial meeting was held at Government House, having been convened by your Excellency in consultation with Surgeon-General Greany and Colonel Forman, and to which representatives of the Royal Army Medical Corps, The Indian Medical Service, The Civil Medical Department, the Sanitary, Bacteriological and Health Departments, and of the Private Practitioners' Class were invited. At that meeting it was resolved among other matters that those present form the nucleus of a Committee to be expanded by them into a Central Representative Committee comprising representatives of all the principal medical departments or associations (official and unofficial) in India; that the programme of subjects and their division into sections be drawn up and arranged by the Central Committee, special prominence being given to Plague, Enteric Fever, Relapsing Fever, Malaria, Animal parasites and disease carriers, Leishman Donovan bodies, Dysentery, Cholera and tropical diarrhœas and sanitation in India; that an Exhibition of Medical, Surgical and Sanitary appliances be held in connection with the Congress including demonstrations, Microscopical, Macroscopical, and lantern slide specimens, and that Lieut.-Colonel W. E. Jennings, I.M.S., be appointed General Secretary and Editor of the Transactions. In the course of a few weeks the nucleus expanded itself into a Committee comprising representatives of the Royal Naval Medical Service, The Royal Army Medical Corps, The Indian Medical Service, Provincial Medical Establishments in India, The Civil Medical Department, The Sanitary Department, The Bacteriological Department, The Health Department, The Bombay Municipal Corporation, Lady Doctors in India, Indian Lady Graduates, Medical Education, The Military Assistant Surgeon Class, The Civil Assistant Surgeon Class, The Faculty of Medicine in the Bombay University, Christian, Parsi, Mahomedan and Hindu Private Practitioners, The Medical Department of Native States, The Hospital Assistant Class, The Medical Missionary Association in India, The Medical Press, The Bombay Branch of the British Medical Association, The Grant Medical College Society, The Bombay Medical and Physical Society, The Bombay Medical Union, The All India Hospital Assistants' Association and Medical Commerce. This Committee split itself up into numerous Sub-Committees including the Executive Sub-Committee, a Procedure Sub-Committee, Sub-Committees for selecting authors of original papers in different sections, Finance Sub-Commitee, a Sub Committee for scrutinizing voluntary papers, a Collecting Sub-Committee and a Sub-Committee for preparing designs for medals, parchments, &c. Captain Gordon Tucker was appointed Assistant Secretary and Secretary to Section I, the other Sectional Secretaries being Khan Bahadur Dr. N. H. Choksey (Section II), Dr. A. Powell (Section III), Dr. S. K. Nariman (Section IV), Dr. S. H. Modi (Section V), Captain Mackie, since succeeded by Captain J. Cunningham (Section VI, Pathological), Dr. Goldsmith (Section VI, Sanitary) and Messrs. Charles White, Wise, Robinson and Ramchandrier (Section VI, Commercial). It was not long before a definite programme was decided upon, and invitations were issued to many of the leading authorities on the subjects to be discussed and of those engaged upon special research thereon in India

and elsewhere, to read papers or submit such to be read on their behalf. Invitations were also sent to certain Medical Societies and Scientific Institutions to send delegates to represent them and to contribute papers; delegates were invited from Great Britain, the Continent of Europe, Japan, the Phillipine Islands, the Malay Peninsula and elsewhere; and other Provincial Governments in India and Native States were invited to send representatives. Besides those invited many members of the profession have sent in voluntary papers several of which have been accepted. The result shown is the varied and interesting programme now before your Excellency from the deliberations upon which it is hoped that a valuable addition to the literature of the Profession will be compiled, and improved means for ameliorating suffering among the masses devised. In order to devote as much time as possible to discussing the many questions involved, it has been arranged that only abstracts of the papers, limited to ten minutes' time duration, be read during the Session, printed copies of the papers themselves having been circulated *in extenso* among the medical members of the Congress, the better to enable them to prepare criticisms and to take part in the discussions. Several of those invited from distant parts, and who have been unable to attend personally, have sent papers to be read on their behalf. Among these we have the names of Sir Lauder Brunton, Professor Unna, Colonel McLeod, Drs. Nash, Fowler, Macy, Whitmore, Dibdin, Maxwell, Scott Moncrieff and others. Sir Lauder Brunton's paper is upon the action of snake venoms, his important researches in which field have led to a method for the local treatment of snake-bite which has saved many lives in India. Much other important research has helped to make this great authority famous, notably his labours in the field of Anæsthesia, his investigations regarding the action of Nitrites on the circulation, and his more recent series of inquiries into the probable causes of race deterioration. Professor Unna who has contributed a paper upon Leprosy is best known for his development of Histopathology. He has made a very careful study by microscopic methods of the pathology of the skin and his results are embodied in a text book which has become classical and has been translated into other languages. Amongst those who have honoured us by their presence from afar are Professors Ronald Ross, Shiga and Musgrave from Liverpool, Japan and the Phillipine Islands respectively. The world is indebted to Professor Ross for the tedious and original investigations by which he has conclusively demonstrated the life cycle of the Malarial Parasite in the anopheles mosquito, and thereby elucidated the mode of infection, and supplied the means of successfully combating Malaria. Professor Shiga has by his labours in the field of dysentery enabled us to undertake the prevention of that scourge on scientific and certain lines, having in 1898 discovered that a large proportion of dysentery cases was caused by a bacillus discovered by him and now known by his name. Professor Musgrave from the Phillipine Islands has by his original work added much to our knowledge of Tropical Diseases and especially of Amœbic Dysentery. Dr. Fowler whose great exertions in the work of Sanitation, and especially in connection with the much vexed question of sewage disposal, has gained him a high rank in this direction has also contributed a paper which, it was hoped he would personally present to the Congress, but he has unfortunately been unable to come in time. From amongst those who have and are making their names in India by their original investigations and patient labours we have several valuable contributions, and many, including Majors Donovan, Lamb, H. Smith, and Leonard Rogers and Captains Greig, Forster, Christophers, Dr. Bentley, Mr. Howlett and others, have come long distances to give us personally the results of their arduous studies. Lastly, we have papers recording results of work carried out more immediately in our midst in the shape of contributions from several Medical Gentlemen (official and otherwise) in Bombay. In order that opportunities for attending the debates should be within the reach of all professional persons, the conditions of admission, as laid down in the Committee's prospectus, have been made so elastic that no holder of a recognized medical qualification, no nurse in uniform or no senior medical student, if properly recommended, need pay any fee for admission. Those wishing to qualify for membership need only pay Rs. 15, which not only entitles them to unconditional admission but also to a free copy of the Transaction Report, and free admission to the Exhibition for one week after the Session. In order to give opportunities to laymen to interest themselves in the undertaking, the Committee offered them membership carrying the same privileges as the above for Rs. 20 each, and several have availed themselves of the offer. I am glad to be able to report to your Excellency that the Profession has come well forward to assist us, and between two and three thousand admission tickets have been issued. The leading Railway Companies have made liberal concessions to those coming from distances of over a hundred miles—a circumstance which has, doubtless, resulted in many more coming than would have otherwise been able to. To aid their work of organization, the Committee have received valuable assistance from public bodies and private individuals in Bombay. The Bombay Municipal Corporation gave a donation of Rs. 0,000 towards the funds, the Trustees of the Port one of Rs. 5,000, and several leading citizens have contributed sums varying from Rs. 100 to Rs. 1,000 each, and assisted in other ways. To commemorate the undertaking the Committee have struck a medal, replicas of which members can purchase on the written authority of the General Secretary or order from him. The dies were made through the kind permission of Colonel Cordue, R. E., the Mint Master, by the Bombay Mint from designs submitted by a Sub-Committee, consisting of Colonel Robinson, R.A.M.C., Miss Benson, and Major Winter, R.A.M.C., who reported that they had received much valuable assistance from Mrs. P. B. Haigh. Upon the obverse of the medal is depicted, in relief, a figure of the Goddess Hygeia with the motto NON EST VIVERE SED VALERE VITA, and upon the reverse the larva and mature forms of the Anopheles Mosquito with the motto VENIENTI

OCCURRITE MORBO and the inscription BOMBAY MEDICAL CONGRESS, 1909. Through the courtesy of the Authorities of the University of Bombay these beautiful buildings have been placed at the disposal of the Committee, and all the Sections, excepting the Sanitary Section, will be held herein. Nearly all the Committee and Sub-Committee meetings have been held in the University Library, and the Committee owe a deep debt of gratitude to Mr. Fardunji M. Dastoor, the Registrar, for his invariable courtesy and for the facilities which he has always afforded for the holding of meetings, &c. In again thanking your Excellency for the deep and unflagging interest which among many and varied arduous duties you have evinced in the Congress, I request you, on behalf of the Committee and Members, to accept this small token as a mark of our esteem and respect, and to formally declare the Sessions open after presenting these medals to those who have honoured us by coming from far countries to help in our proceedings.

Presentation of Medals.

A gold replica of the Congress Medal was then presented to His Excellency, who, in his turn, presented medals to Professor Ronald Ross, Professor Musgrave, Professor Shiga, Captains Jones, Ford and Nicholls of the United States Army, and Dr. Van Loghen from Sumatra. His Excellency then delivered the following address, and declared the Sessions open.

Presidential Address by His Excellency the Governor, President of the Congress.

Ladies and Gentlemen, - Surgeon-General Stevenson has given us an excellent sketch of the measures taken to organize this Congress and of the scope of the many important subjects with which it will deal. He has also referred to the great assistance it has received in the form of valuable papers from members of the profession in India and in distant countries, of contributions to our funds from generous public bodies and private citizens of Bombay, and of special fares granted by the Railway Companies. I wish to take this public opportunity of expressing my warm thanks to all who have helped to confer upon this Congress the success which we confidently anticipate, and which would have been unattainable without that cordial co-operation of many workers, directed upon a well-arranged plan, which constitutes good organization.

I desire also to offer a cordial welcome to all our distinguished visitors from other parts of India and especially to those who have come to us from across the sea. We are deeply indebted to the Governments of the United States and of Japan for allowing Professors Musgrave and Shiga, two eminent representatives of Medical Science, to honour our proceedings, while Professor Ronald Ross has left important work at Liverpool to give us the benefit of his great knowledge of the malaria-bearing mosquito. This year is not exactly an anniversary of one of the great land marks of medical progress; but we have only just passed a most important jubilee. Pasteur's researches in 1858 into Vinous fermentation demonstrated the fact that the phenomena of fermentation were due to micro-organisms, and this must be regarded as the real starting point of the germ theory of disease which has already revolutionized many branches of medical practice and will eventually carry us far beyond our present visions. I suppose that Jenner, when he established vaccination in 1798, was not far from this theory; but for sixty years the secret remained hidden. Pasteur's great discovery however, suggested to Lister that putrefaction and suppurative processes were due to bacteria and in 1867 he established the antiseptic treatment of wounds. The immediate result of this great advance was to give a powerful impetus to surgery. I remember well that at this period, we were gravely assured and we believed that medicine had almost spoken its last word, and had become mainly empirical, and that the future of curative science evidently lay with surgery.

This was a peculiarly unfortunate prophecy, and it may serve as a useful warning against the tendency to set a limit to scientific knowledge and progress. Startling discoveries destined to throw a fresh light on the causes and the processes of the worst of epidemic diseases and eventually to revolutionize their treatment, were close at hand, and followed in quick succession.

Thus Koch, in 1876, isolated the bacillus of anthrax in pure culture, and, in 1882, he discovered the tubercle bacillus and demonstrated the relation of this micro-organism to the disease. In 1883, the bacillus of diphtheria was described by Klebs, and in the following year it was successfully cultivated by Loeffler. In 1883, also, Koch isolated the cholera bacillus in pure culture from persons suffering from this disease, and during the years 1888 to 1890 Roux and Yersin proved that the important features of diphtheria could be produced by the separated toxins of the diphtheria bacillus. Meanwhile in 1880, the fact that Protozoa may cause disease was brought to light by Laverean's discovery of the malarial parasite and Professor Ronald Ross, after patient and persistent search, discovered the parasite in the mosquito. In 1885, Pasteur published his classical researches, which inaugurated the present treatment of wounds received from hydrophobic animals—a treatment now carried on in two institutions in India with the most beneficial effects. Meanwhile, Japan had entered upon the field of bacteriology with marked success, and Professors Kitasato and Shiga discovered the plague and dysentery bacilli in 1894 and 1898, respectively.

I have given only the most cursory summary of the great discoveries of this fruitful period. The point I wish to lay stress upon is that within a short time the Medical Profession obtained knowledge which turned upside down opinions matured during centuries, and opened up endless vistas of further research. As soon as the germ theory was established and it became possible to cultivate a bacillus with as much certainty as a cabbage, new methods of combating disease were evidently possible and were eagerly sought. The use of drugs in relation to diseases ascertained to be of bacterial origin, assumed a new aspect, and empiricism could be thrown to the winds. Prophylactic and curative sera became objects of careful and prolonged experiments, and already

the use of these sera has led to the saving of life on a very large scale. The opsonic treatment, the technique of which has been elaborated with infinite care and skill by Sir Almwoth Wright, is a development directly based upon the germ theory, which is giving excellent results in certain cases of tubercular disease and of infection due to pyogenic organisms

The revolution of thought in regard to disease opened up wide fields of investigation of another kind. The old ideas of the transmission of infection and of the spread of epidemics no longer sufficed, and fresh explanations had to be sought. I may mention the excellent work done at Parel in regard to the transmission of plague as a good instance of successful scientific research. Quite recently it has been discovered that persons, who have been in contact with enteric fever cases, may harbour the germ and transmit the disease without being themselves affected, and that persons who have had enteric fever may be capable of transmitting it for months or years after they have recovered.

While modern medical progress may be said to be based upon the use of the microscope, other scientific developments have come to its aid. Advances in electrical discovery produced the X and other rays, which, with the sciagraphic processes dependent on them, have proved most valuable for purposes of diagnosis. The curative power of these rays is already established in certain cases and there can be little doubt that more will be accomplished in this direction. The marvellous discovery of radium and of radio-activity by Madame Curie in 1903 entailed a reconstruction of some of our ideas in regard to this matter. Already there is reason to believe that radium possesses curative powers, while its peculiar properties make it exactly adapted for local treatment. Now that radium is to have an Institute to itself, there can be no doubt that it will be forced to reveal its medical secrets.

Finally I may mention the tonic treatment arising from the discovery that an electric current can be employed to carry a chemical substance to an internal part of the body. This treatment is also in its infancy.

I hope that I have not wearied you with this crude survey of the astonishing progress of medical science in recent years. I think that perhaps it seems more wonderful to an outsider like myself than to those who have played a part in promoting it. Within little more than forty years we have seen a veritable revolution. Science provided new means of investigation, which were quickly turned to account, and at the same time scientific methods were brought to bear upon medical research with the most striking results. The medical profession is now scientific in the highest sense of the term. I can remember the time when this could not have been said without reservations. I believe that no other profession has before it so many fields plainly inviting research. Certainly no other profession has open to it such entrancing possibilities of conferring benefits on humanity.

I should like to mention two striking instances of what medical science has accomplished of late years. When I was at Malta, the death-rate from what was vaguely known as "Malta fever" was high, and the number of cases very large. We, engineers, used to spend our time trying to find causes of pollution of the water supply which did not exist. Then came Major Bruce who isolated the bacillus, worked out its biology, which was mainly associated with goats and their milk, and converted Malta into a healthy station. The second instance is the excellent work of the United States Army Commission at Panama in 1900. The discovery by means of scientific research that yellow fever is conveyed by a mosquito may almost be said to have rendered possible a vast engineering work which will powerfully influence the commerce of a part of the world.

Bacteriology is still in its infancy, and valuable discoveries await the investigator who can bring patience and scientific methods to bear upon the many problems of disease. Good work is being carried on here in India, as the Papers to be read in this Congress will prove; but much more remains to be undertaken. Visiting many hospitals as I have done since I came to India, I have frequently seen charts of the fevers of the country and I have been told that their character is obscure, and that the ordinary blood examinations give negative results. Here I believe, is one of many fields of enquiry in which the knowledge that is power may be gleaned.

The Congress, as Surgeon-General Stevenson tells us, has thrown its net far and wide. I earnestly trust that the papers read and the interchange of views thus arising will give a fresh impetus to medical progress in India. Germs of thought may surely be evolved, which will blossom into achievement. Our students may feel inspired to high aims, and will at least realise that their College training is only an introduction to the study of modern medical science. I am hopeful that the vernacular papers, many of which have helped to disseminate facts about plague serum, will assist us in spreading knowledge of a general character in which India is sadly deficient.

Lastly, I am sure that this Congress will emphasize the essential solidarity of the noble profession of healing which knows no distinction of race or colour, and unites all true workers as members of one great brotherhood engaged in combating suffering and disease throughout the world.

And now, gentlemen, I have the honour to declare this Congress open and I trust that it will prove a landmark in the history of medical progress.

VOTE OF THANKS.

A vote of thanks to His Excellency the Governor was then proposed in a few well chosen words by Surgeon-General A. T. Sloggett, C.M.G., who said that, as time was pressing, he would not make a long speech, but on behalf of the members of the Congress, and of all present, could assure His Excellency that what the speech lacked in quantity was made up for by the quality of the warmth of the thanks tendered to him. Every one present there that day was well aware that the Congress owed its very existence to the initiation of His Excellency who had not only started it, but had, from the very first, watched its progress with sympathetic interest. They had all listened to the very interesting speech of His Excellency in which

MAIN ENTRANCE OF THE EXHIBITION.

he had really given an epitome of the progress of Medical Science and Research during the last 30 or 40 years; a speech which was not that of an amateur, but that of an expert who had realised and mastered the fact of the importance of medical science, not only for the welfare of the Natives of India but for the future welfare of the whole world; and one in which he had alluded so warmly to the great services rendered to science and humanity by the Officers of the Royal Army Medical Corps and Indian Medical Service, services which though apt to be too often forgotten had nevertheless gained the sympathetic appreciation of His Excellency, possibly because of his belonging to a sister scientific service, the Royal Engineers, which ever worked hand in hand with the Medical Services for the betterment of the condition of the soldier. He felt sure that the wish His Excellency had expressed that the views interchanged at this great Congress would give a fresh impetus to the advancement of Medical Science would be fulfilled; and, before concluding, gave expression to the gratification felt by all at seeing Miss Clarke present, whose keen interest in Medical Scientific work was so widely known, a fact of which he himself had had personal experience. He begged to propose a cordial vote of thanks to His Excellency for presiding at the opening ceremony.

Professor Ronald Ross, C.B., in seconding the proposition, referred to His Excellency's unflagging interest in popularizing science and to the great delight with which he and his colleagues from distant lands had come to lend their aid to an undertaking which owed its origin to so distinguished a scientist as His Excellency. He considered that success was assured not only because of the presence of the many earnest workers assembled for the interchange of views, but largely because of the keen stimulus afforded to one and all by the watchful interest taken by His Excellency in every detail which could possibly conduce to success. He had much pleasure in seconding the vote of thanks.

The proposition was enthusiastically received by one and all as evidenced by the warm and prolonged applause.

His Excellency and Party were then escorted by the General Secretary to inspect the Pathological Exhibition and the work of the sections was at once started, the President of each opening his own section in the Hall appointed.

Section I.

CHOLERA, DYSENTERY, ENTERIC FEVER, TROPICAL DIARRHŒAS AND MISCELLANEOUS.

Sectional President.

SURGEON-GENERAL A. T. SLOGGETT, C.M.G., P.M.O., 6th (Poona) Division.

Vice-Presidents.

COLONEL R. H. FORMAN, R.A.M.C., P.M.O., Bombay Brigade.
LT.-COLONEL W. J. BUCHANAN, M.D., I.M.S. (Editor, *Indian Medical Gazette*).
DR. RAJABALLI V. PATEL.
DR. A. NAVE, F.R.C.S.

Secretary and Sectional Editor.

CAPTAIN E. F. GORDON TUCKER, I.M.S.

Assistant Secretary.

DR. F. N. KAPADIA.

Introductory Remarks by Surgeon-General A. T. SLOGGETT, C.M.G.

Before formally declaring the section open, Surgeon-General Sloggett referred to the importance of the subjects to be dealt with in the Section and to the very interesting contributions which had seen sent in. He felt sure, he said, that the deliberations thereon would result in much benefit to all, and, after formally declaring the section open, he called upon Major Leonard Rogers to read his paper upon Cholera.

CHOLERA WITH SPECIAL REFERENCE TO ITS TREATMENT.

By Major LEONARD ROGERS, M.D., F.R.C.P., F.R.C.S., I.M.S.

It was with much pleasure that I accepted the flattering invitation to open the discussion on cholera to-day, as the subject has for many years greatly interested me. It was the great Indian outbreak from 1817 to 1823, closely followed by its spread to Europe between 1826 and 1834, which furnished the basis for the first accurate modern descriptions of the disease. The second Indo-European epidemic of 1840-49 was noteworthly for the publication by Snow and William Budd of their water-borne theory of infection, although it was not until after a third terrible visitation a decade later that it was accepted and acted on in England. The sixth Indo-European outbreak of 1879-83 will ever be memorable for Koch's discovery of the comma bacillus, which at last placed the ætiology on a firm basis, and allowed of simple measures being adopted to prevent, or at least greatly limit, the epidemic waves, which were spreading over Europe and America with ever increasing frequency, with the opening up of more rapid communications with the East, after the construction of the Suez Canal. In India improved sanitary control of the great pilgrim camps has also much lessened the dissemination of the disease.

Ætiology.—The comma bacillus of Koch is now practically universally recognised as the cause of cholera, although the labours of D. D. Cunningham in Calcutta, and of many others, have shown the serum test; in addition to cultural characteristics, is necessary for its differentiation from non-pathogenic water organisms. The mode of infection can best be described in Ernest Hart's terse saying, "You can eat cholera and you can drink cholera, but you cannot catch it." The well known predisposing effects of fasting, chills and the use of saline purges during cholera only require mention. The much greater prevalence of cholera among visitors to endemic regions, than among permanent residents, first pointed out by H. M. Macpherson, is probably due to fractional inoculation through repeatedly digesting comma bacilli, producing some degree of immunity among the better class.

Diagnosis.—As it is unnecessary to describe the symptoms of cholera to such an audience as this, I will pass on to the differential diagnosis. This is easy in typical cases, while mild or doubtful ones may safely be treated as cholera, without waiting for a bacteriological confirmation of their nature. The resemblance of the algide type of malaria to cholera should always be borne in mind, as its early recognition by finding the parasites in the blood is essential to its successful treatment with quinine. Ptomaine poisoning may cause difficulty, but in several cases of this disease I have found the absence of the typical leucocytosis of cholera of great value in their differentiation. A very severe dysentery may easily be thought to be cholera on first admission before the stools have been inspected.

Mortality.—In the earliest outbreaks the mortality of cholera was underestimated through incorrect diagnosis. Later in 1860 Morehead gave the mortality among natives treated at large civil hospitals, such as the J. J. Hospital, Bombay, at from 60 to 65 per cent. During a series of recent years I found it to be 61 and 63 per cent. respectively at the Medical College and Campbell Hospital, Calcutta. In European General Hospitals Morehead gave the mortality at 50 to 55 per cent., but during the last ten years at the Calcutta European Hospital it has been 69 per cent. From 1903 to 1906 the mortality in British and native troops and jails respectively has been 72, 63 and 59 per cent. It is clear from these figures that there has been no reduction in the mortality in recent years as a result of the vast amount of research on bacteriological lines. Prophylactic inoculation, although of undoubted value, has not been found feasible on a large scale in India. The extremely high mortality at the beginning of an epidemic, followed by a gradually decreasing one throughout its course, to sometimes reach but about half the initial rate, must always be carefully borne in mind; for it has often led to condemnation of valuable remedies used at first, and laudation of worthless ones administered to later cases.

Pathology.—I only propose here to deal with some points which have a practical bearing on the treatment. The most essential is the relative importance of the action of toxins produced by the comma bacillus, and of the effects of loss of the fluids of the body respectively in producing the lethal effects. The finding of powerful toxins produced in cultures of the comma bacillus does not prove that they enter the circulation in fatal doses. I have injected as much as ten c.c. of the serum of fatal cholera cases into small animals, such as pigeons, rats and rabbits with no ill effects unless given intravenously, when intravascular clotting occasionally took place, which is probably due to an albumose and related to the partial vaso-motor paralysis present in severe cholera cases. I have also recently estimated the actual loss of fluid from the blood with the hæmocrite, and may here summarise my results by saying that in the severest fatal cases it averaged 64 per cent. of the total; in cases requiring transfusion, but who recovered, the loss was 52 per cent., and in the milder cases not requiring transfusion it was but 35 per cent. There is thus an absolute relationship between the severity of the disease and the loss of fluid from the circulating blood, which finally disproves George Jhonson's statement to the contrary, and affords invaluable guidance in treatment. For reasons which will appear presently, I have also estimated the amount of chlorides in the blood, ex-

pecting to find them much above the normal as a result of its concentration. The results, on the contrary, showed that in the worst cases of cholera the chlorides were lowest, being not infrequently between 0·6 and 0·7 per cent. or below the normal for Bengalis on whom I was working; the salts also escaping in the stools as shown long ago by Edmund Parkes. Moreover, if the salts in the blood were raised to 1 per cent. or over, recovery nearly always ensued. The bearing of these facts will be obvious, as I think it will be admitted that the loss of from one-half to two-thirds of the total fluid and salts from the blood, with a corresponding loss from the tissues, must produce an extremely critical state of the circulation, demanding immediate relief by the only possible method of replacing the deficiency by some means or other. At the same time any toxins present in the blood will be greatly diluted, and their excretion through the kidneys and alimentary tract, which has necessarily come to a standstill with the failure of the circulation, will be actively promoted.

As microscopical examinations of the kidneys in fatal cholera uræmia made me suspect an actual mechanical obstruction to the circulation of the blood through the renal vessels, I have measured the pressure required to freely run normal salt solution through the kidney circulation *post mortem* in both healthy organs, and those who had died in the uræmic stage of cholera. In the former from 20 to 30 m.m. sufficed, while in the latter 90 to 100 m.m. was required—a most striking difference, the practical importance of which will appear presently.

Treatment.—This must be considered separately as regards three stages, namely, firstly, that of copious evacuations, secondly of collapse, and thirdly of reaction with its complications, especially uræmia. In the premonitary and evacuation stages we have to consider the two diametrically opposite lines of either encouraging or restraining the vomiting and purging. The evacuant plan has now been universally abandoned. Macnamara, an enthusiastic pupil of Johnson himself, as a result of his experience with castor oil in India, recorded that "It absolutely and completely failed; the mortality from the disease was fearful." Moreover Johnson's theories are now finally disproved and remain but an interesting relic of medical history.

Drug Treatment in the Pre-collapse Stage.—In view of the fact that the case mortality of cholera has certainly not been reduced in India during the last seventy years, the treatment adopted by older Indian writers is of great importance. I have carefully studied them, but can here only give a very brief summary. In the days of Annesley and Twining (1832) copious bleedings and violent purges were universally used in all conditions thought to be inflammatory, which included cholera. Yet Twining, who bled so much in fevers, warns against its dangers in all but the very early stages of cholera. Moreover the inevitable 20 to 30 grain doses of calomel was always tempered by full doses of opium in cholera by the physicians of that time. With these exceptions their treatment of the disease scarcely differed from that which has prevailed up to the present day. Thirty years later, in the time of Morehead, Goodeve and Macnamara, bleeding and large doses of calomel had been finally abandoned, while opium remained the sheet anchor in the pre-collapse stage of cholera, being now combined with astringents, such as acetate of lead and dilute acids. In 1893 Wall's book on the subject appeared, and his great experience emphatically endorsed the same line of treatment, while he also enthusiastically advocated the use of saline injections, which the antiseptic era had now rendered much safer than when they were first introduced by Mackintosh and Latta in Edinburgh in 1831. The one fact which stands out prominently from these writings is the universal opinion as to the great value of large doses of opium in cholera, the present comparative neglect of which is, I think, a retrograde step. In the premonitory diarrhœa there is general agreement that opium can cut short the disease, while in the more advanced stage of copious evacuations Wall advises Tr. Opii min. 12 with Acid. Suph. Dil. min. 10, to be repeated in two hours if necessary. If rejected by the stomach he gave 12 minims of the liquid extract of opium subcutaneously, greatly preferring this to morphia, and found that in a large number of cases it prevented collapse, after the onset of which it is too late for this remedy. Goodeve gave two grains of opium, or 40 minims of laudanum, while Macnamara used opium with acetate of lead or dilute sulphuric acid. For sometime past I have been giving morphia hypodermically to every other cholera patient admitted within the first two days of the disease with, I think, some benefit, but have not seen any approach to the invariable cures recently reported from Sylhet. Regarding the use of calomel in small doses there is much greater difference of opinion, Goodeve stating that it got its reputation owing to its doing no harm, while Wall condemns it as being altogether injurious. It is possible that the drug may help to re-establish the flow of bile as Annesley maintained, but I doubt if this is sufficient to counteract its dangerous purgative effects. If given at all it should be in $\frac{1}{4}$ grain doses, repeated several times. Camphor has also been recommended as a stimulant, especially in Paris, but its value is at least doubtful. The value of the long catalogue of other drugs which have been extolled is probably in inverse ratio to their number. The question of the use of alcohol in cholera is a very vexed one, many observers from Corbyn to Macnamara utterly condemning it, the last named considering it to be "both theoretically and practically an unmitigated evil." Goodeve and Wall, however, cautiously recommend it in small doses. The great objection to it appears to me to be its tendency to increase the vaso-motor paralysis, so that it is very rarely advisable in native patients, and only occasionally in Europeans who have been accustomed to its regular use. When given its effects on the pulse and blood pressure should be carefully watched. Ammonia may be substituted with greater safety.

Measures to replace the Fluid lost from the System.—Once the blood pressure has sunk to a very low point, or

complete collapse has ensued, drugs are not only useless, because not absorbed, but become positively dangerous, as they accumulate in the alimentary tract, and later may enter the circulation during the stage of reaction in undesirable quantities. Either nothing but frequently repeated small quantities of water or ice may be administered and the patient left to take his chance ; or active measures to rapidly restore the ebbing circulation must be adopted, the following methods being available in the latter alternative. When the violence of the initial diarrhœa has abated, leaving a pulse of fair volume and a blood pressure of from 60 to 80 mm. in natives, saline enemata of from one-half to one pint should be administered every two to four hours. In mild cases this will suffice to tide the patient over the threatened collapse, or to prevent its recurrence after revival by intravenous transfusion. If relied on, a most careful watch must be kept for any further sinking of the pulse necessitating more active measures, because marked collapse may ensue at any moment, especially if renewed watery evacuations occur.

The next most simple measure is subcutaneous injections over the chest, axilla or thighs, which appears to have been introduced by Wall, and has been largely used in India during recent years. About half a pint is usually injected in one or more places, and if any pulse remains it is rapidly absorbed. There are two serious objections to this method. Firstly, owing to the low vitality of the tissues in cholera, abscesses frequently follow in spite of great care in the administration. Secondly, my observations on the serum and specific gravity of the blood before and after cholera transfusion show that in any case requiring saline injections it is generally useless to administer less than three pints, while four are usually required to reduce the concentration of the blood to, or better a little below, the normal point : an amount which cannot conveniently be given subcutaneously. In all severe cases, therefore, we have to fall back on the use of intravenous saline injections, which unfortunately require considerable technical skill and time, seriously limiting their general applicability in India. Moreover, although the immediate effect in restoring the circulation and relieving the cyanosis, cramps and restlessness are simply marvellous: yet the ultimate results have hitherto been extremely disappointing, for only too often the diarrhœa rapidly recurs, all the improvement being frequently lost within a few hours. Wall rightly insists that it should be repeated again and again, and mentions success being attained after six transfusions but admits that as many as 70 per cent. of his patients died. Goodeve remarks that " owing to no means having been found to keep the fluid in the vessels the method just missed being a great and glorious discovery." In my own experience, in conjunction with Captain J. W. D. Megaw, I.M.S., this method produced only a slight reduction in the mortality on account of the same recurrence of the diarrhœa which has baffled all previous workers, and intravenous injections were once more almost entirely abandoned at the Calcutta Medical College Hospital.

It then occurred to me that the failure might be due to diluting the concentrated blood by the normal saline solution (0·6 per cent. NaCl.) which has nearly always been used and that what was required was to replace the lost fluid, and at the same time maintain a high percentage of salt in the blood, which would tend to cause the osmotic current to carry fluid into the vessels, rather than allow it to escape from them. The remarkable success which has attended the intravenous injections of hypertonic salt solutions in cholera has already been recorded and time will only permit me to mention that among 175 cases treated in the first nine months of 1908, during the very virulent epidemic then prevailing, the mortality, including all late moribund and complicated cases, has been only 33 per cent. or but little more than half the rate of several previous years, and that too although it was frequently impossible to transfuse as many as one should have liked. I must not omit to mention that all the hard work of carrying out this method has fallen on Captain Maxwell Mackelvie, I. M. S., who deserves the fullest credit for his successful labours. Favourable reports of its use in a few cases have also reached me from several quarters.

The continuous method of intravenous transfusion of Cox should also be referred to, as it is reported to have given good results in his hands in Hongkong. With the hypertonic solution used in Calcutta, namely, 120 grains of sodium chloride (with 3 grains of calcium chloride, owing to the frequent great decrease of the coagulability of the blood) to one pint, a single rapid injection of four pints usually suffices to permanently tide over the collapse stage, but in some cases it has to be repeated.

Owing to the technical difficulties of intravenous transfusion rendering it inapplicable in India except in well-equipped and staffed hospitals, I have devised a canula for easy and rapid intra-peritoneal injections, which has been used by the Assistant Surgeons and Hospital Assistants at the Campbell Hospital, Calcutta, in a temporary mat shed with earth floor, with an encouraging degree of success, under the superintendence of Major J. C. Vaughan, I. M. S., to whom I am greatly indebted for so kindly giving the method a trial under conditions which afforded a reliable guide to its general feasibility in India. It consists of a small silver-plated steel tube, with one end sharpened like a cork borer and a flange two inches above to prevent it slipping in too far. A blunt stilletto suffices for cleaning the tube when necessary. A small incision is made with a tenotomy, or other narrow bladed knife, through the skin and fascia of the anterior abdominal wall just below the navel, where the peritoneum is adherent. The tube is inserted into the wound, and with a boring movement can readily be made to enter the peritoneal cavity without any chance of injuring the intestines. From 3 to 4 pints can readily be run through in about ten minutes, the little operation being thus much quicker and easier than intravenous injections. If any pulse remain, the fluid is rapidly absorbed, so that it can be used in all but absolutely moribund patients, in whom immediate intravenous

injection is essential. An abdominal binder applied after the injection both slightly raises the blood pressure and facilitates absorption. The injections can easily be repeated through the same perforation, a superficial stitch and some collodion on cotton wool being afterwards applied. When a large number of cases have to be treated with a small staff, this method promises to be of great value.

Lastly, a few words remain to be said on the treatment of uræmia. The *post mortem* renal transfusions already mentioned led me to watch the blood pressure day by day in the reaction stage of cholera patients, with the result of showing that this complication most commonly occurs when the blood pressure does not rise above 100 m.m., while at higher ones urine is readily excreted. One man, with deep stertorous breathing of 42 to the minute and almost absolute unconsciousness, made a good recovery on his blood pressure being forced up from a little under 100 to 110 by hyperdermic injections of adrenal and digitalin. Hot-air baths have also been of value once full reaction had been attained by large transfusions. Cupping over the kidneys should never be neglected.

In the limited time allowed I have only been able to touch on the salient features of the treatment of this appalling disease. I venture, however, to hope that the hypertonic transfusion in collapse, and blood-pressure-raising treatment of the uræmia may prove sufficiently successful in other hands to do something towards removing the, not altogether unjust, reproach of C. Macnamara, when he wrote : "I must say, however, that it appears to me the profession in India require a little gentle stimulation in this direction. It would seem as if we had almost abandoned ourselves to despair in the matter of the treatment of cholera : doubtless, the task is beset with difficulties, but this should not depress, but rather stimulate, research, where the good of our fellows and the honor of our profession are so deeply concerned. The solution of the question, I repeat, is one which pre-eminently devolves upon men living in the endemic area of cholera, and it is to us, therefore, that the profession in Europe naturally turn for information on these matters."

ON THE TREATMENT OF CHOLERA.

By Khan Bahadur N. H. CHOKSY, M.D. (Hon. Causâ), Freiburg,

Special Assistant Health Officer, Bombay Municipality, in charge of Arthur Road Infectious Diseases and Maratha Plague Hospitals, Bombay.

The main desideratum in the treatment of cholera being a simple and effective treatment, any attempt in this direction is worthy of notice. The reasons why the treatment should be simple are sufficiently obvious, inasmuch as during severe and widespread epidemics, with hastily improvised and inadequately equipped hospitals, manned with staffs drawn at short notice from various quarters, any line of treatment requiring elaborate or expensive apparatus with special technique and entailing too great a demand upon individual attention on the part of the Medical Officers, especially when large number of patients have to be treated, is bound to be beyond the resources of such institutions, apart from the physical difficulty of its application. The treatment therefore should be such, as could be easily carried out by nurses or hospital assistants with the aid of the menial establishment. It is in this direction that the treatment has been carried out at the Arthur Road Hospital since 1900, the results of which I beg to lay before you.

The indications sought to be fulfilled were as under :—

(*a*) To destroy the virus and to neutralise its toxins if possible; (*b*) to supply the loss of fluid to the system depleted by the flux; (*c*) to keep up the circulation and restore and re-establish the functions of the kidneys ; (*d*) to nourish the patient or rather to withhold all irritating nourishment ; (*e*) to tide the patient over the stage of reaction ; and (*f*) to treat complications and sequelæ, and symptomatic treatment.

(*a*) To destroy the virus *in situ* and to neutralise its toxins require a powerful and at the same time an innocuous germicide or a bacteriolytic serum as well as an antitoxin. The latter appears to be within probable reach. In the meanwhile, various germicides have been employed with varying success, such as quinine, carbolic acid, solution of perchloride of mercury, solution of terchloride of iodine, salol, dermatol, tribromophenol bismuth (xeroform), &c. Whilst conducting some observations with the last, during the epidemic of 1900, Dr. Alfons Mayr, then of the Municipal Serum Laboratory, suggested to me the use of the cyanide of mercury. The dose we decided upon to administer was one-tenth of a grain with simple syrup and water made up to one ounce every two to three hours according to the stage of the disease and frequency and character of the motions. It became soon noticeable that it exerted a marked influence in controlling the frequency and altering their character, the typical rice-water stools being replaced by bilious ones. In the algide stage, when diarrhœa has all but ceased, only a few doses were required, but in early cases, if properly exhibited, its effects were well marked. The only drawback to its use was stomatitis during convalescence. If the doses are, however, well regulated according to the gravity of the case and frequency of motions, and rapidly reduced as improvement sets in, many patients escape it altogether.

(*b*) The choice of means for restoring to the system the loss of fluid is limited to but three : (1) transfusion

of saline fluids, (2) hypodermoclysis, and (3) enteroclysis. The first is not easy of application in epidemic times, requiring skilled assistance and other facilities, and was not adapted.

Major Leonard Rogers of Calcutta* has recently described his observations with transfusions of normal salt solutions and hypertonic solutions. He has studied the condition of blood-pressure in cholera by the Riva Rocci apparatus, and has found that transfusion rapidly raises it from 50-60 mm. of mercury to 100-115 within a few hours. Rogers and Mackelvie have further demonstrated the beneficial effects by hypertonic solutions (2 drachms of common salt to the pint), of which four pints are transfused at a time and repeated according to the state of the blood pressure. They assert that the number of deaths during the collapse stage has been greatly reduced, the recurrence of watery stools is much less common with the hypertonic, and the mortality rate has been reduced to about one-half of what prevailed before this method of transfusion was adopted. They describe a general improvement in the condition of the patient, which is almost identical, although more rapid than what follows from rectal injections. These observations are of immense value, but they do not underlie the main desideratum of this paper, inasmuch as measurements of blood pressure with the necessary apparatus, sterilization of the transfusion apparatus, strict asepsis and careful watch over the patient are hardly to be maintained under the conditions in which epidemic hospitals have to be run especially in the outlying parts of the country.†

The second, apart from being painful, often gives rise to cellulitis in spite of all aseptic precautions, and entails prolonged convalescence and tardy recovery. Reliance had therefore to be placed on the last, and rectal injections of one pint of normal salt solution made with boiling water and cooled to about 100° F. were administered at intervals of four hours. If the hips are well elevated and the injection given very slowly by a gravitation douche raised to about four to five feet above the level of the bed, with a soft rubber tube inserted high up from 10 to 12 inches, it is painless without discomfort to the patient, and is almost always retained indicating the possibility of rapid absorption ; occasionally an ounce or two may be expelled after an hour or so. It is not however practicable to give the injections, if the frequency of stools is great, nor is it required in the early stage if the drain from the system could be checked. But in the advanced and collapse stage such injections are of great utility as the fluid is rapidly taken up by the system and by diluting the blood renders it less viscid and therefore easy of circulation. Circulation is thereby restored as indicated by the rise of blood pressure and urinary secretion is stimulated. Under their influence the patient loses that haggard and pinched appearance so characteristic of cholera ; the flesh does not appear shrunken, nor the eyes sunken and hollow—in fact, the aspect of the patient in most of the cases is placid and not at all typical of cholera. The frequency of the injections is gradually reduced as the patient improves and after the urinary secretion has become freely established they are stopped.

(*c*) The third indication to keep up the circulation and to restore the functions of the kidneys is met partly by the measure above detailed and partly by the use of drugs acting directly as well as indirectly upon the heart and the kidneys. With this object the following formula is employed in doses of 20 minims in an ounce of water administered every two, three or four hours according to the stage of the pulse :—

Caffeine sodio-salicylate	grs. 2½
Sparteine sulphate	gr. ½
Liquor atropinæ (B. P.)	m 1
Spiritus vini Gallici	ad m. 20

Coldness of the extremities and profuse clammy perspiration are readily controlled by the atropin ; in addition, hot water bottles or foot and body warmers, sinapism to the calves, and friction of the limbs with dry ginger powder are often resorted to. Hot linseed poultices to the abdomen and loins are continually kept on and changed every two or three hours. In order to encourage urinay secretions if defective in spite of the above measures, poultices of digitalis leaves are utilized and often dry cupping is supplemented with good results. The above measures are in most cases effective in keeping up the circulation and re-establishing the function of the kidneys.

(*d*) The all-important question of nourishing a cholera patient presents many difficulties. The extreme irritability of the stomach and the almost total inhibition of all digestive and absorptive powers indicate that the alimentary system should be freed from further irritation. The stomach instantaneously repels all irritants—even the blandest nourishment is but an irritant at the time—and sounds a warning to hold the hand. The alimentary tract must be given enough time to throw off the poison and to recuperate itself until its natural functions become re-established. Absolute physiological rest is thus indicated and should not be withheld. It is best therefore to stop all food and all alcoholic preparations, the latter considerably aggravate the irritability of the stomach, are generally rejected no sooner administered, and without doing any material good to the patient exhaust him by frequent rejections. If they are administered with the object of stimulating the heart, it is defeated, inasmuch as each effort at vomiting adds to the exhaustion and restlessness of the patient. No alcohol, no milk, and no meat preparation is a salutary doctrine under the above conditions. The only nourishment—could it be so called—allowed is hot

* *Indian Medical Gazette*, March and May, 1908.

† Capt E. J. O'Meara, I.M.S., of Mizapore, prefers (*Indian Medical Gazette*, October 1908) taking the specific gravity of the blood to measurements of the blood-pressure during treatment with saline transfusions in cholera. He says that blood pressure is liable to considerable and sudden variations, apart from the transfusions, and describes the method he has adopted in determining it. He agrees with the present writer that injections into the cellular tissue are not to be recommended especially as there is no absorption from them. If the latter is possible, administration of fluids by the stomach in very small quantities, taking care to avoid overdistension, or by the rectum, is to be preferred.

black coffee without milk and without sugar. This is administered day and night as frequently as the patient requires a drink. It is usually retained and quenches thirst far better than cold fluids. It is curious to notice that excessive thirst and that wide craving for cold liquids so characteristic of cholera are absent among the patients treated on the above lines, the cyanide probably soothing the irritability of the stomach which is not otherwise irritated, and the rectal injections supplying the fluid to the system, and thus relieving thirst indirectly. The patients bear the deprivation of food well, and even among children the distress from its absence is not so evident as one would be led to expect.

Black coffee is generally administered for three to five days‡ until the functions of kidneys are restored and there is a change in the character of the stools. Thereafter thin arrowroot conjee, slightly sweetened, is allowed, to which subsequently milk is gradually added. After the disappearance of all acute symptoms plain biscuits, rice and milk, plasmon, and later fresh mutton broth are allowed.

(*e*) As the stage of reaction is but a manifestation of toxæmia it requires careful watching. It is, however, not well marked nor invariably present in the cases treated by the above method. Violent fluctuations of temperature are practically unknown, the body warmth, already so well sustained, gradually returns to normal without attaining to any great height, and the danger always associated with this stage is practically non-existent. The treatment becomes thus considerably simplified, inasmuch as, before this stage is reached, the greater portion of the toxins has been eliminated and the risk of acute toxæmia altogether averted. High temperature reaching to 104°F. is but rarely observed, and acute delirium which occasionally accompanies it is also of equally rare occurrence. An alkaline mixture containing sodium bicarbonate, citrate of potash with tinctures of digitalis and nux vomica is all that is needed, as it acts both as a diaphoretic and diuretic. Antipyretics are not necessary. Should the delirium be acute, the bromides with tincture of hyoscyamus are indicated. If very violent, hyoscine hydrobromate or even morphine may be required subcutaneously.

(*f*) Symptomatic treatment may be required for occasional persistent vomiting, for after-diarrhœa or for prostration and, sometimes, to encourage the sluggish functions of the kidneys which after partial efforts at reaction appear to lapse again. Persistent vomiting is controlled by cocaine hydrochloras in doses of one-eighth of a grain dissolved in a tea-spoonful of water or mistura pepsine composita *c.* bismuth (sine opio) in ten-minim doses administered every quater or half an hour until four doses have been administered. Crushed ice is sometimes also useful. The after-diarrhœa can be treated by bismuth or, better still, by dermatol. Prostration is overcome by hypodermic injections of camphor (camphor 2, ether sulphuric 3, and olive oil 7) in doses of 20 minims every two or three hours. The measures above described for encouraging urinary secretions have to be re-employed with greater vigour. Dry-cupping over the loins is especially useful and may be freely used.

‡ Capt. O'Meara also does not allow any food for 72 hours, and sometimes even for 5 days.

The only sequelæ requiring attention are parotitis and stomatitis from the cyanide. They are treated on general principles.

Results.—The above line of treatment has been adopted in 533* cases of cholera admitted in all stages of the disease during three visitations and a few sporadic cases. There were 276 deaths and 257 recoveries, the recovery rate being 48·3 per cent. Previous to the adoption of this treatment, 930 patients were treated with 700 deaths and 230 recoveries, the recovery rate being 24·8 per cent. These results show that the recovery rate was doubled under this treatment. The above results, although favourable, cannot be compared with those obtained by Rogers and Mackelvie; they are, however, sufficiently striking and demonstrate that, under ordinary circumstances, rectal injections give a fair chance of success, although transfusion of salines is to be preferred wherever facilities for its adoption are available.

DISCUSSION.

Dr. A. Neve.—I have had experience of two severe epidemics, and have realized the futility of pouring drugs into the stomach after the first stage. Opium given by the mouth may be retained, accumulate, and subsequently in cases which would otherwise have recovered, cause death. Prof. Leonard Rogers' valuable paper draws attention to the critical demand in bad cases arising from the de-hydration of the blood, which becomes too viscous to circulate. Saline enemata sometimes do good; I have seen decided benefit from hypodermoclysis, but large quantities cannot thus be given without danger of sloughing. Intravenous injection is the most rapidly effective measure, but it is a difficult operation in such cases, and has its risks in the usually intensely septic Indian surroundings. Intra-peritoneal injection is far simpler, and may prove of great value. I hope it will be widely tested, and we should look forward to its use with renewed confidence in treatment. The hypertonic solution as recommended by Major Leonard Rogers should be rapidly absorbed.

Capt Henry J. Nichols, Medical Corps, U. S. Army.—We have recently had an epidemic of cholera in Manila and have arrived at the same conclusions as Maj. Rogers in regard to the necessity for increasing the fluid content of the blood during collapse. In fact we have come to believe that if intravenous injection of saline solution is thoroughly used patients should not die of collapse unless there is some special reason such as old age or infancy or some coincident disease. In our opinion there is no inherent reason why the collapse stage of cholera should be so fatal as it usually is in epidemics. It should rather be classed with curable conditions like diphtheria and malaria. Of course patients cannot be saved without a good deal of trouble and expense, but it seems to us simply a question of ways and means—a question of doctors and nurses, of salt solution and inclination—to very appreciably reduce the mortality from collapse.

On the other hand we found we could do little for uræmia. We lost about 20 per cent. of patients from collapse, and another 20 per cent. from uræmia, leaving the total death-rate still high; but as in the intravenous injection of salt solution we already have a means of combating collapse, we may turn our attention more to uræmia and hope to find some means such as Major Rogers' blood pressure determinations and vast motor stimulants, or something else which will proportionately reduce the death-rate from uræmia.

* One hundred and twenty cases were practically in extremis and succumbed within 6 hours of admission. If these were to be excluded, the recovery rate would be 62·23 per cent.

Dr. Joseph Benjamin said:—During the sixties and seventies of the last century calomel was the sheet anchor of treatment in cholera on this side, the dose given being five grains for adults. A medical man who had seen the treatment used has told me that the results were favourable. Afterwards the capsicum treatment came into vogue. Government issued bottles of Mistura Choleræcum Opio and Mistura Choleræsine Opio. These were largely used in cholera epidemics, especially at the time of the Deccan famine of 1877. Those whose duty it was to administer these mixtures have informed me that whereas the latter did good the former did harm ; immediate distension set in, and death ensued in the majority of cases. Spirits of Camphor, and Chlorodyne, were also largely used in the eighties and were found very serviceable, especially when given in the beginning of an attack. Then followed instructions from Government to administer quinine and dilute sulphuric acid to patients suffering from this disease. This treatment was largely used in jails at the time and was favourably reported on. I have myself seen good resulting from the administration of dilute sulphuric acid in this disease. After this carbolic acid had its day. Alcohol also has had its advocates, but it has now mostly fallen into disuse. Some medical men now give aromatic spirits of ammonia, spirits of chloroform, tincture of cardamoms and tincture of digitalis in this disease, Major Rogers advocates intravenous injection of saline solution. The results have no doubt been encouraging, but in private practice there will be great difficulty in carrying out the treatment, whereas rectal saline injections as mentioned by Dr. Choksy in his paper can be more easily carried out, though of course the latter cannot be so efficacious as the former. As liquids are generally rejected by patients, rice water gruel or whey to which a pinch of salt is added, may be given in small quantities. For the cramps mustard plasters and hot water bottles are serviceable. Some use hypodermic injections of morphia in cramps. Friction of the parts also does good in such cases. For the suppression of urine, hot water bags or bottles to the loins, and linseed poultices, are useful. In some cases slime and blood are passed in the stools after the first rice-water stools. Such cases prove rapidly fatal. During suppression of urine, spirits of nitrous ether should be administered internally in addition to cupping, etc. My own opinion is that opium should be avoided as far as possible in cholera, even in the commencement, chlorodyne being given in its stead if necessary. As the thirst is great, pieces of ice should be given to suck, and mustard plasters to the heart, when the pulse is feeble. Musk is largely used in native medical practice in this disease. Milk should not be given for two or three days, but only arrow-root or sago congee without milk may be given after the second day.

Dr. H. D. Pant.—I find my experience of the treatment of cholera does not correspond with that of Major Rogers in one important point. In my hands opium has not only failed but it has done actual harm in cases of true Asiatic Cholera. Of course I leave aside cases of so-called Choleric diarrhœa due to nervous fright for which opium may and often does act as a soothing agent. But when rice-water stools have appeared the administration of opium is unsound in principle and unsafe in practice. The free and indiscriminate distribution of cholera pills containing opium, camphor and assafœtida, in the villages through the agency of vaccinators and compounders as is practised in our parts cannot be too strongly deprecated. Camphor and assafœtida are two very excellent things during cholera epidemic.

I have now had twenty-two years' experience. The first half of my professional life was spent in treating cholera on orthodox allopathic principles, free use of opium, liquid food and stimulants during collapse.

Ten years ago when I set up practice in Lucknow I found our school of medicine at a great discount. Hakims and Homeopathy held their sway over the whole town during the cholera season.

The public is very shrewd. I at once assumed that there must be something wrong in our system of treatment that had turned people away from us.

Repeated failures with opium had made me very suspicious of its use, so I rejected it. I followed Hakims in restricting diet altogether. My line of treatment is almost the same as that recommended by Dr. Choksy in his paper. Instead of Cyanide of Mercury I give Calomel gr. $\frac{1}{8}$, Camphor gr. $\frac{1}{2}$, Cerii oxalas gr. 1 and Pulv. Tragacanth. gr. 1 every quarter, half, one or more hours according to the severity and the needs of the case during the evacuation stage. It checks vomiting and gives bile to the stools. The powder is put upon the tongue. This is the only medicine I give and ice is the only food or drink I recommend in this stage.

Hypodermic injections of camphor, rectal injection of saline solution and teaspoonful doses every quarter or half hour of a solution of Permanganate of Potash gr. $\frac{1}{2}$ to oz are my sheet anchors during collapse. What effect the Permanganate has and how I came to adopt it, I am unable to explain. Suffice it to say that the use of this drug has satisfied me and my patients by giving force to the wavering and flickering pulse. Of course I do not minimise the value of mustard, ginger powder or dry cuppings.

Plain strong hot coffee is the food and drink for this stage, water is not restricted.

In the suppression of urine a mixture of Spt. Terebent. m. 1, Tr. Cannabis Indica m. 1 with Spt. Æther. nitrosi and mucilage given every half hour does wonders. I have seldom found it to fail and if it does fail I give up the case as a bad job for nothing else has succeeded in my hands so well.

The reaction stage I leave to nature. Plain water and plenty of it is called for. If you avoid opium and prohibit food absolutely during the first two stages you will have very little inflammatory fever in the 3rd stage. The fear of starvation has done much harm to cholera patients.

Khan Bahadur Dr. N. H. Choksy.—I have not much to add to the excellent resumé of Major Rogers in relation to the treatment of cholera. He and I are in substantial agreement as regards the indications to be met: the choice of means has to be left however to the facilities available as I indicate in my paper on the same subject. He agrees with me that technical difficulties militate against the universal adoption of intravenous injections. If further experience with the intraperitoneal method shows it to be more adaptable, it is sure to meet with professional favour. I entirely endorse his recommendations with regard to the use of cupping over the kidneys, which is often supplemented by poultices of digitalis leaves at the Arthur Road Hospital ; it has been found of great use in stimulating the sluggishness of those organs. From my experience of cholera at Bombay, I am enabled to cordially support Major Rogers' concluding remarks re : the necessity of "a little gentle stimulation" of the profession in this direction. The time has arrived when with fuller knowledge of the pathology of the affection and improved and more exact and rational methods of treatment, there should be no excuse in resorting to antiquated methods that have been proved over and over again to be useless. The treatment of cholera to be successful must be early and prompt, and based upon rational principles ; there is no likelihood of our drifting into erroneous channels if the main principles are kept in view. With regard to the use of the anti-cholera serum, Simond applied it at my hospital in 1897, but without marked success and such I am given to understand has been the experience of Salimbeni and his co-adjutor in the recent epidemic at St. Petersburg. The average Russian of the lower classes does not appear to differ very much from the native of India in his repugnance to and suspicion of Hospital treatment to which he resorts, or is compelled to, when too late.

Dr. T. M. Nair said :—I do not think that Major Rogers has sufficiently emphasized the uselessness of treatment by the internal administration of drugs in the reaction stage of cholera. Absorption from the intestinal canal is not only delayed, but even stopped during an attack of cholera. Major Rogers admits

this fact so far as the reaction stage is concerned. But I am of opinion that even in the collapse stage and in the stage of copious evacuations absorption from the intestinal canal is practically at a standstill. Treatment by the internal administration of drugs in these stages, therefore, is not only useless but may even be positively harmful. Repeated doses of powerful drugs administered during the stage of copious evacuations may remain unabsorbed in the stomach, if they are not thrown out by vomitting, and may when reaction sets in be absorbed and produce symptoms of poisoning. I have myself been called in consultation to a case of cholera in the stage of reaction. The patient had been freely treated with opium in the evacuation stage and I found him suffeing from opium poisoning in the stage of reaction. I admit the correctness of the treatment of the premonitory diarrhœa of cholera by the internal administration of drugs such as opium. But I think the time has come to record an emphatic protest against the internal administration of drugs—no matter what drugs they are—in the collapse stage of cholera. Hypodermic medication may be of use in these later stages of cholera when administration of drugs by the stomach is likely to be injurious.

But when the stage of copious evacuation is over, and the patient is left almost pulseless, the only treatment of any value that is left is the injection of saline solution by the intravenous method. By this treatment, in the past, many lives have been saved. The treatment is scientifically correct, but presents some difficulties in its practical application. The performance of the operation of intravenous injection requires a certain amount of technical skill which is not generally possessed by the majority of medical men who have to deal with the treatment of cases of cholera. And secondly it requires also a certain amount of time for its satisfactory performance which is a great difficulty when large numbers of cases of cholera have to be dealt with almost simultaneously during epidemics of that disease. It is to minimise these two difficulties that Major Rogers has suggested the intraperitoneal injection of saline solution instead of the intravenous. One can sympathise with the suggestion but unfortunately it is of doubtful efficacy. The class of cases in which injections of saline solutions are likely to be resorted to are those in which the patient after the evacuation stage is left almost pulseless. If the patient has a fairly good pulse at the close of the evacuation stage we may trust to nature to bring him round safely. But where the pulse is feeble and the blood pressure low, it is then that the necessity for the injection of the saline solution comes in. And it is exactly in those cases that intraperitoneal injections as suggested by Major Rogers, or rectal injections as suggested by Dr. Choksy, are likely to fail. To cause the absorption of the injected fluid either from the peritoneal cavity or the rectum we require a certain amount of blood pressure. And that is precisely what we have not got. And the result will be that the injected fluid will not be absorbed and the patient will receive no benefit from the treatment. I am afraid that neither the intraperitoneal nor the rectal injections will be of any good in cases where the patient in almost pulseless—the very class of cases in which the intravenous method is urgently called for. In my opinion the intraperitoneal method cannot by any means be considered an efficient substitute for the intravenous. And I am not at all certain that in unskilled hands the performance of paracentesis abdominis is altogether free from danger.

Major Leonard Rogers, I. M. S.—Several speakers have referred to the dangers of excessive doses of opium in cholera, and doubtless it is such cases which have led to the reaction against the use of this drug, which I think has been pushed too far. If only one or two doses are given before complete collapse has ensued, as I have advised, no harm can result, and much benefit may accrue. It has been stated that there is no absorption during the stage of evacuation. This is probably true as regards the intestines, but not of the stomach, while if opium or morphia is given subcutaneously, as advised by Wall, it will be absorbed as long as some pulse remains. The rectal injections advised by Dr. Choksy are not retained in severe cases, and have been used by all workers for a long time past in milder ones as I have mentioned in my paper. I have recently given the double normal strength saline by the mouth instead of plain water, and find it is readily taken by cholera patients, but have not yet sufficient experience to say if it is beneficial. It has also been suggested that during collapse there will be no absorption from the peritoneal cavity. This is not the case, as the injection of three pints there at once raises the blood pressure appreciably by lessening the accumulation of blood in the portal system due to vaso-motor paralysis, and it can be still further raised by an abdominal binder. In one case the blood pressure was thus immediately raised from 45 mm. to 73, and three hours after had reached 88, by which time no free fluid could be detected in the abdomen. The next day it was 100, and urine was being passed freely, an uninterrupted recovery ensuing.

Uræmia occurred in two classes of cases. Firstly, in very severe ones admitted early, in whom the blood pressure remained low for several days, not rising above 80 or 90, and secondly in mild cases admitted two days or more after the onset, who had also had continued low pressure from want of treatment. It might be expected that one result of tiding so many patients over the collapse stage of cholera would be a larger proportion of deaths from uræmia to the total admissions. A comparison of the records of 1908 with very numerous transfusions, with those of 1907, when scarcely any were done, showed, however, that the deaths from uræmia were slightly fewer in the former year. This must be due to the effect of the transfusions in early raising the blood pressure, and I look to the more frequent and early use of this measure to still further reduce the mortality, now that in the hypertonic solutions we have a method of checking the rapid loss of the injected fluids. The intravenous method is the best when available, but in severe outbreaks it is rarely that the staff is sufficient for the purpose. Under such circumstances I believe the intraperitoneal method I have described will save many lives.

OUTLINE OF AN EXPERIMENT TO DETERMINE THE

VALUE OF COLORED UNDERCLOTHING

For United States Soldiers Serving In The Phillipines.

By Capt. J. M. PHALEN and Lieut. H. J. NICHOLS, *Medical Corps, U. S. Army.*

We wish to say frankly at the outset that our object in presenting this paper is to profit by discussion rather than to attempt to instruct and accordingly we shall simply give an explanation of what is being done by the U. S. Army in the Phillipine Islands in regard to the effects of Tropical light, in the hope that this account, even if it contributes nothing, may be of some interest here in India where the climatic conditions have given rise to so many observations on this subject. During America's short occupation of Tropical countries, a number of men, but notably Major Woodruff of the Army Medical Corps, have become impressed with the possibilities of the effect of Tropical light on white men and have brought this question into prominence. Dur-

ing England's long rule in the Tropics, however, the question has been considered more thoroughly and the immediate cause of the work to be outlined is found in two articles by Sambon and Duncan in the Journal of Tropical Medicine of February and March 1907. Sambon, it will be recalled, photographed the spectrum of an electric arc after passing the rays through the skin of a native of India and then constructed wearing material for white men which had the same effect. Duncan's article was prompted by Sambon's and he gave practical instances from India to support Sambon's theories with recommendations in regard to clothing. These articles came to the notice of the Inspector General of the Phillipines Division and he urged that the matter be looked into. General Wood approved with the remark that "while the effects of the sun in these islands and in the hotter portions of India are very different, yet it is believed that it would be wise to have a careful investigation made as to the advantage to be derived from the use of underclothing of a color to protect against this (the actinic) ray."

These recommendations were approved at Washington and on advice of the Surgeon General 5,000 suits of the regular issue underwear and 5,000 hat linings were dyed orange-red, the color selected being in the words of the Surgeon General "as nearly as practicable that used by photographers to prevent chemical effects of the light used in their dark rooms and for the same reason." The matter was turned over to us for execution with directions that half of a company wear the colored underwear and the other half act as controls, and that a special medical officer stay with the troops for a year to observe the results.

The question may suggest itself, why should this experiment be made ; why not adopt the clothing outright? For us there are two reasons. In the first place the whole subject is in a somewhat hypothetical state. Neither the effects of light nor the remedies proposed are on any such firm ground as the need for sterilized water or mosquito nets and light clothing in the Tropics. Enthusiasts who have perhaps more fondness for ethnology and analogy than actual experience make it seem quite plain. Others perhaps equally biassed hold that the ills of tropical life are all included in the results of infection, heat and moisture. Take for instance a sunstroke as an example of the unsettled state of opinion. Duncan's article is entitled "The Actinic Theory of Sunstroke" and he says there can be no doubt that this actinic theory of sunstroke is the correct one. Manson, however, says that in his opinion Sambon's hypothesis of the infectious nature of Siriasis has more in its favor than any of the many theories that have been based on a purely thermic ætiology. On the other hand Rogers has shown, quite conclusively it seems to us, that sunstroke is co-related with a high temperature and a certain degree of moisture in the air.

In the second place we have to deal with soldiers, and with soldiers in the Phillipine Islands. This fact narrows the field at once. If the ultra violet rays are injurious it would undoubtedly be of value to wear colored glasses to protect the retina ; this is not feasible however for soldiers who would discard them on the slightest provocation. Again soldiers' clothing, for Military purposes, is already to a certain extent pigmented and certain articles of clothing, such as the hat, are fixed beyond change. Again in the Phillipines we have practically no sunstroke although it is common enough in some seasons and places in the United States.

It seems desirable therefore that we should satisfy ourselves of the value of these suggestions for our own conditions and environment before acting finally upon them.

Granting for the sake of trial that the actinic rays are injurious to the white men's tissues, how can we measure and demonstrate these effects. Sun-stroke must be excluded as it is so rare ; heat exhaustion is by common consent admitted to be due to heat rather than light. There remains a group of complaints called sun traumatism by Manson, and we have a small number of cases which may be included in this group. The chief results, however must be sought for under the rather vague headings of neurasthenia and anæmia.

Neurasthenia.—If loss of physical and mental tone is measurable in objective terms it has seemed to us that dynamometer and blood pressure readings should show it, and these are the special tests, one for the voluntary muscle nerve apparatus and the other for the involuntary, that we expect to rely most upon. These observations will be made at least every three months.

Anœmia.—Some work has already been done by medical officers on the blood and among nearly 100 men observed over a year by Capt. Wickline, there was an average loss of over 10 per cent. hæmoglobin ; an increase of the number of red blood cells and an increase of lymphocytes and decrease of polynuclears. Similar observations will be made on the men wearing colored underclothing, and on controls.

500 subjects with 500 controls have been selected from cavalry, infantry and artillery in 4 widely separated posts. After excluding men with long tropical service and those who are for any other reason unfit, every other man in order of height has been ordered to wear the clothing, and the other men to serve as controls. A special medical officer has been detailed at each Post to keep the records and to observe the results. The records are kept on cards which require besides the special test mentioned the following data ; age, height, nativity, color of hair, color of eyes, complexion, length of service, and length of tropical service ; an account of previous medical history and medical history during the test ; weight, pulse and respiration.

In addition to these 500 men 75 men are to be studied more closely with the ergograph and blood pressure readings for effect of short exposures to the sun. A number of officers of the line and staff are also wearing the clothing and their opinion will be considered.

Some information has already been obtained by exposing photographic plates to sunlight after passing through

the articles of our uniform. The most interesting result is that our campaign hat, which is apparently fixed for field work, is as opaque to chemical rays without a red hat lining as with it as is shown in the accompanying figure. As the lining increases the heat, it seems doubtful if the hat lining will be of any benefit for the campaign hat; for caps there is a slight difference for the orange-red lining over the ordinary lining colored green, brown or red. Our blue flannel shirt however is not as protective chemically as we had believed. We have other prints showing the absorptive power of each article of clothing. Other questions have come up such as the fastness of the dye, the increase of heat of colored clothes, the relative value of a less gaudy garment, etc.

At present we are merely in a receptive mind; and while we believe that at the end of this test we can give some definite opinion on the merits of colored underclothing for our soldiers, at present we are in the strictly agnostic mood.

DISCUSSION.

L. Rogers, I. M. S.—Dr. Nichol's investigations are of great interest and importance in the tropics. Lt. Colonel Andrew Duncan, I. M. S. (Retired) has long advocated orange or red coloured materials for lining helmets and for the protection of the spine. He suffered several times from heat-stroke before adopting that precaution, but subsequently escaped through its means. Dr. Nichols has referred to my work on heat stroke. In this I showed that with certain degrees of heat and moisture in the air heat-stroke cases were liable to occur, the incidence being thus readily explainable on purely physiological grounds, so that there was no need for any hypothetical microbe as its cause. Heat stroke, however, occurred in barracks etc., without any exposure to the sun's rays, and must be carefully distinguished from sun-stroke, due to the direct action of the sun, and greatly predisposed to by fatigue and alcohol. The latter occurs frequently in temperate climates during exertion on hot days. In one form it was syncopal in nature, as in cases of sudden death during heavy exertion in a hot sun in one of the China wars. The subject of protection against sun-stroke requires further investigations, and Dr. Nichol's work will be watched with interest. Somewhat similar trials are being conducted in Calcutta.

PREPARATION, DISTRIBUTION AND USE OF CALF VACCINE IN THE TROPICS.

By Capt. F. H. G. HUTCHINSON, M.B. (Edin.), D.H.P., D.T.M. & H. (Camb.), I.M.S.,
Deputy Sanitary Commissioner, S. R. D.

It is obvious that the use of fresh calf vaccine on a large scale is not feasible; for even in England where the distances are small, and intercommunication easy, fresh calf vaccine is almost invariably replaced by calf vaccine diluted with glycerine. It has frequently been urged that glycerinated vaccine is quite unsuitable for use in the Tropics, and that some diluent possessing little or no heat conductive power should be used. Lanoline and vaseline have both supporters. If, however, it can be shewn that glycerinated calf vaccine can be used successfully by Vaccinators distributed over a wide area of tropical country, no decision in favour of either lanoline or vaseline is possible unless it can be proved that one or the other possesses a bactericidal power at least equal to that of glycerine, or that the vesicles from the use of lanolinated or vaselinated vaccine are superior in quality to those after vaccination with glycerinated calf vaccine.

The Belgaum Vaccine Institute has been working for over 7 years, and at first only prepared lanolinated vaccine. It was found that cases of ulceration, of delayed healing, and of axillary abscess occurred more frequently than after arm to arm vaccination, so for the past 5 years an effort to introduce glycerinated vaccine has been made with varying degrees of success. The want of uniformity in results pointed to errors in technique, the elimination of which has led to complete success. A description of the methods at present in force may prove of help to some and of interest to others. The chief obstacles to the preparation of a potent vaccine in the Tropics are (*a*) the condition of the calf and (*b*) temperature of the air.

Calf Management.—A calf is seldom received in fit condition for vaccination, it is usually emaciated. Emaciation is due to either inanition or disease, and generally to a combination of both. In this part of India cattle are allowed to graze, but are not given food unless the food of the owners depends on the efforts of the cattle. Owners will not part with their calves until they are weaned, so it is not surprising that the calves received are thin from inanition. Experience in Belgaum shows that 3 diseases—piroplasmosis, rinderpest, foot and mouth disease—lead to emaciation. Of the 3 diseases piroplasmosis appears to be the most important, and also the most common. It occurs during the cold months, that is at the time most suitable to calf vaccination. An epidemic resulting up to the time of writing in some 80 deaths has interfered greatly with the work at Belgaum for the past 2½ months. It would also seem that infected animals do not respond satisfactorily to vaccination for a very considerable period. Warning is usually received of rinderpest, and inoculation can be practised as a precaution, but it is well to remember that a large percentage of calves do not respond well to vaccination for a fortnight to three weeks after inoculation.

Foot and mouth disease is not fatal, but renders a calf useless for a Vaccine Institute as recovery is very slow. The prevention of these diseases is a matter of the first importance as all are contagious and new arrivals must be rigorously isolated until proved free of infection.

During isolation attention should be paid to the following points:—

(*a*) Destruction of ticks by the immersion of the cattle in a special dip. In Belgaum an emulsion of arsenious acid, soap and tar is used.

(*b*) Examination of blood films from each calf and with frequent examination if necessary of all emaciated calves or of those exhibiting a temperature above normal.

(*c*) Rejection of all calves shewing evidence of foot and mouth disease.

After isolation the calves are admitted to the waiting stables for rest and food preparatory to vaccination. Rest is just as important as food, and it must be remembered that in the Tropics the blood sucking insect is well able to deprive both man and beast of rest. In the Belgaum Vaccine Depôt the great rest disturber is the stomoxys, dozens are sometimes found on each calf. It is also by no means uncommon to find the larvæ of flies belonging to the Genus Lucilia in vaccine vesicles. To protect the calves against flies two precautions are essential :—

(1) Cremation or burial of all stable refuse.

(2) Fly proof stables and calf inoculating room.

Calf Vaccination.—In selecting a calf for vaccination attention must be paid to the colour of the hair. The best colour is white with red patches, the next most favourable being pure white or light chestnut. In Belgaum the majority of calves have hair of dark colour, but the skin is frequently unpigmented. Pigment in the skin is unfavourable to the development of vesicles, but is not a contraindication to the use of the calf. A calf with a pigmented skin generally yields a vaccine quite potent enough for human vaccination, but never fit for " stock" purposes, as the virulence of the vaccine is rapidly lost by passage through calves. The skin on the abdomen and on part of the chest is used for vaccination, not the skin on the inner side of the thigh. The best vesicles are generally found near the umbilicus.

Straight incisions are made with a sharp scalpel, the edge of which is moistened with calf vaccine ; a separate insertion of vaccine is afterwards made with the blunt edge of the scalpel. No rubbing in is necessary, but is disadvantageous: any damage to the skin seems to interfere with evolution of the vesicle by causing acceleration and rapid drying. When the vesicles show that the stock vaccine is degenerating, the best vaccine in stock is passed through one or more series of children. Children, when available, seem better for this purpose than rabbits. It may not be amiss here to emphasize the desirability of a Vaccine Institute in the Tropics possessing a motor car. To keep a stock vaccine of first class potency a fairly frequent interchange between the child and calf is necessary. In towns parents are not willing to allow " lymph" to be taken from their children, hence it is necessary to go to the villages. In a hot climate speed is essential. Again it is often necessary to test the potency of some of the " despatch vaccines." This can only be satisfactorily done on children ; if the test is to be real the vaccine should be exposed as far as possible to the treatment it would receive after issue to the Vaccinators. It should be carried by a peon on foot to villages some 6 to 15 miles distant. Thus a motor car would be of real utility, not a luxury, and one suited for rough use should be purchased, not one designed for luxurious travelling.

"*Pulp Extraction.*"—As acceleration sometimes occurs, the calves are inspected after 96 hours and it is found that the pulp has sometimes to be removed after 102 hours, but if the stock is potent, and vaccination is carefully performed, acceleration is not common. The vesicles are scraped while the skin is put on the stretch, care being taken to prevent mixture with free blood. Only typical vesicles are scraped, the most perfect being set apart for " stock vaccine."

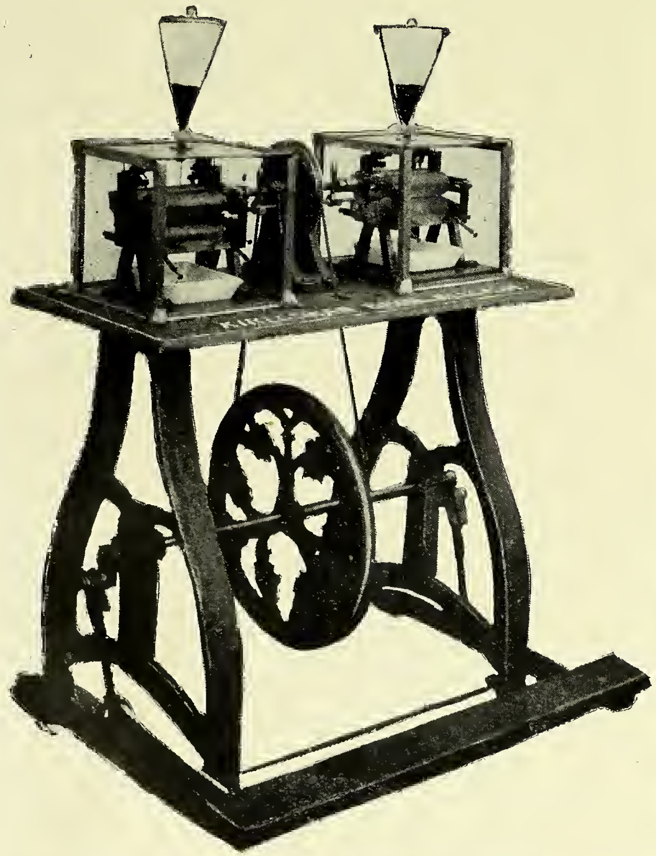
Mixing the Vaccine.—The pulp is weighed, and then ground down with 4, 5 or 6 times its weight of a 50 per cent mixture of glycerine and sterile distilled water. The grinding is naturally done under cover as in the tropics a strong wind is generally blowing, and raising much dust in the dry season. In Belgaum the best results have been obtained with Doring's lymph grinding machine modified as the photograph attached shows (Plate I). The machine was fitted up by Messrs. Kirloskar Bros. of Belgaum, and can be attended to by one man. After 3-5 passages a perfect emulsion results. The time occupied is about 15 minutes.

The only advantage over the Chalybaus machine as modified by Dr. Blaxall is cheapness ; the emulsion is every bit as good, while the double machine as shewn in the photograph is no more costly than a single Chalybaus machine fitted to be driven by foot.

Purification of the Vaccine.—Two forms of calf vaccine are prepared—glycerinated calf vaccine and glycerinated calf vaccine after the passage of chloroform vapour. Owing to defective storage arrangements only a comparatively small amount of glycerinated vaccine can be stored for the time requisite for purification ; for this reason the majority of vaccine issued has up to date been subjected to the passage of chloroform vapour.

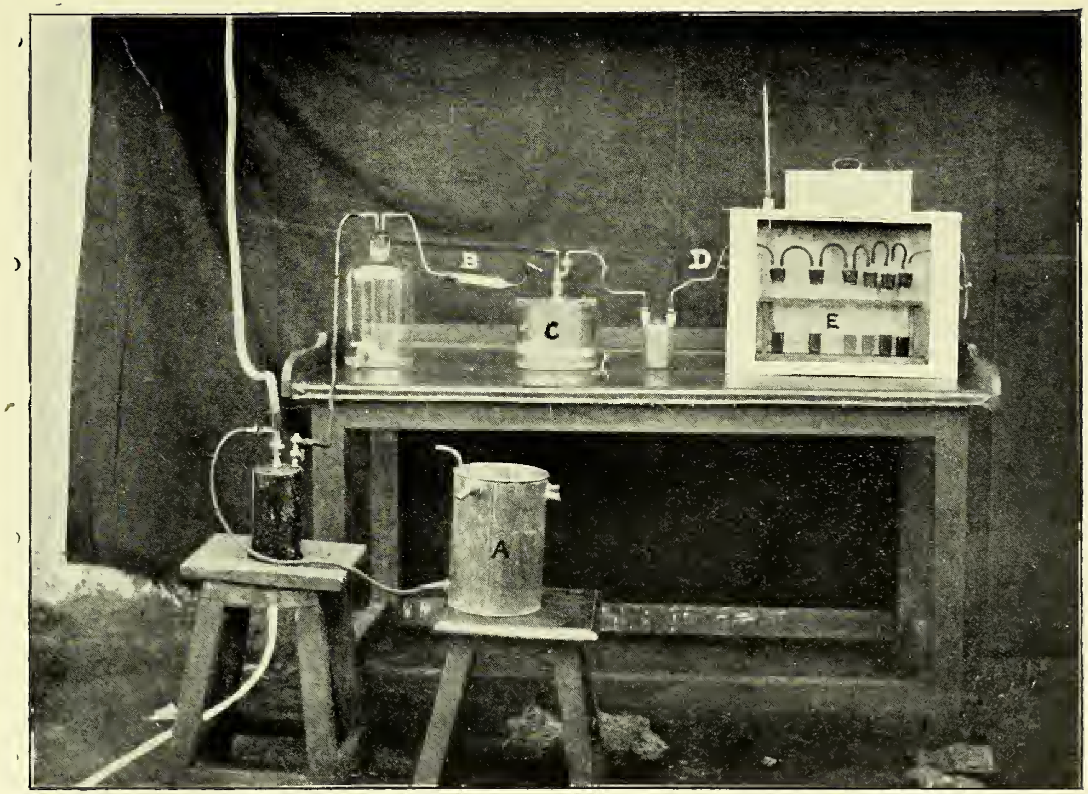
The process as carried out in Belgaum differs slightly from that recommended by Dr. A. B. Green ; adverse results due in large measure to tropical conditions have suggested a few modifications. A photograph of the plant used is attached Plate II). The cool chamber for the tubes of vaccine can be made out of kerosene oil tins at small cost, it is surrounded on 3 sides by a water jacket, the water in which is cooled by ice or freezing mixture, the front being closed by a sliding glass door. The temperature of the air in the chamber is kept at 18°C., while chloroform vapour is being passed through the vaccine. The blowing away of the excess vapour takes some hours and it has proved advantageous to reduce the temperature in the chamber with freezing mixture to from 10° to 12°C. During certain months of the year room temperature is from 28° to 35°C. So an attempt has been made to reduce the temperature of the air drawn through the plant by causing the air to pass through coils surrounded by cold water or freezing mixture according to the air temperature. The chloroform bottle itself is placed in a cool chamber. During hot weather stock chloroform is kept in an ice chest. Chloroform vapour is passed through the emulsions for 2 hours in the monsoon, and for $2\frac{1}{2}$ or 3 hours in the dry weather. If every detail is carefully attended to this is sufficient in nearly every case to produce a sterile vaccine. In the

Plate I.



Doring's lymph grinding machines, with glass covers and feeds and fitted to be driven by foot.

Plate II.



CHLOROFORM PROCESS.

A. Condenser worm for cooling air.
B. Wool filter.
C. Cool case for wash bottle containing chloroform.
D. Clip for controlling passage of chloroform vapour.
E. Cool case for tubes of vaccine.

Plate III.

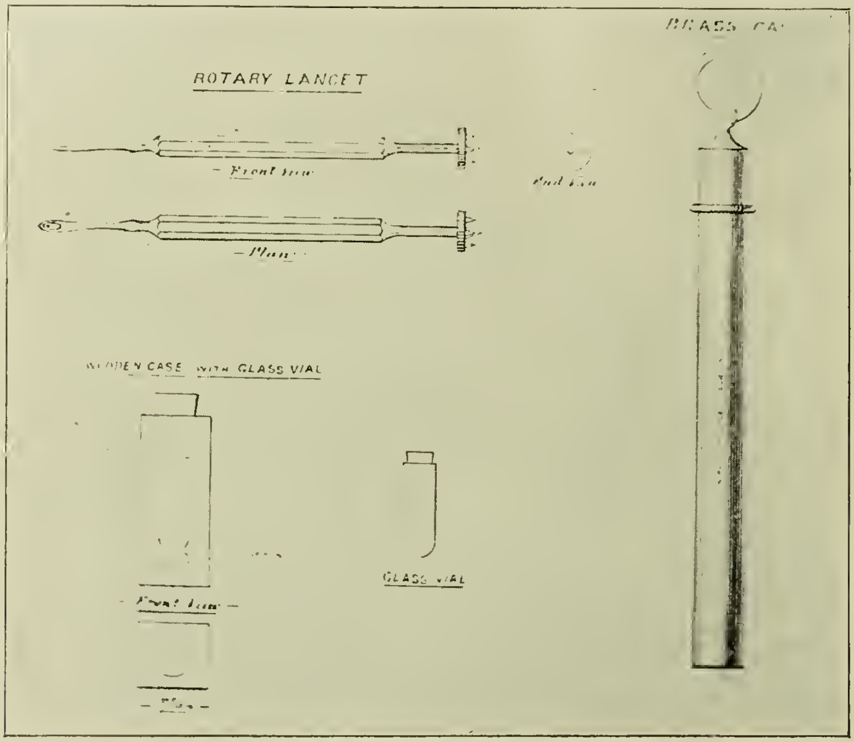
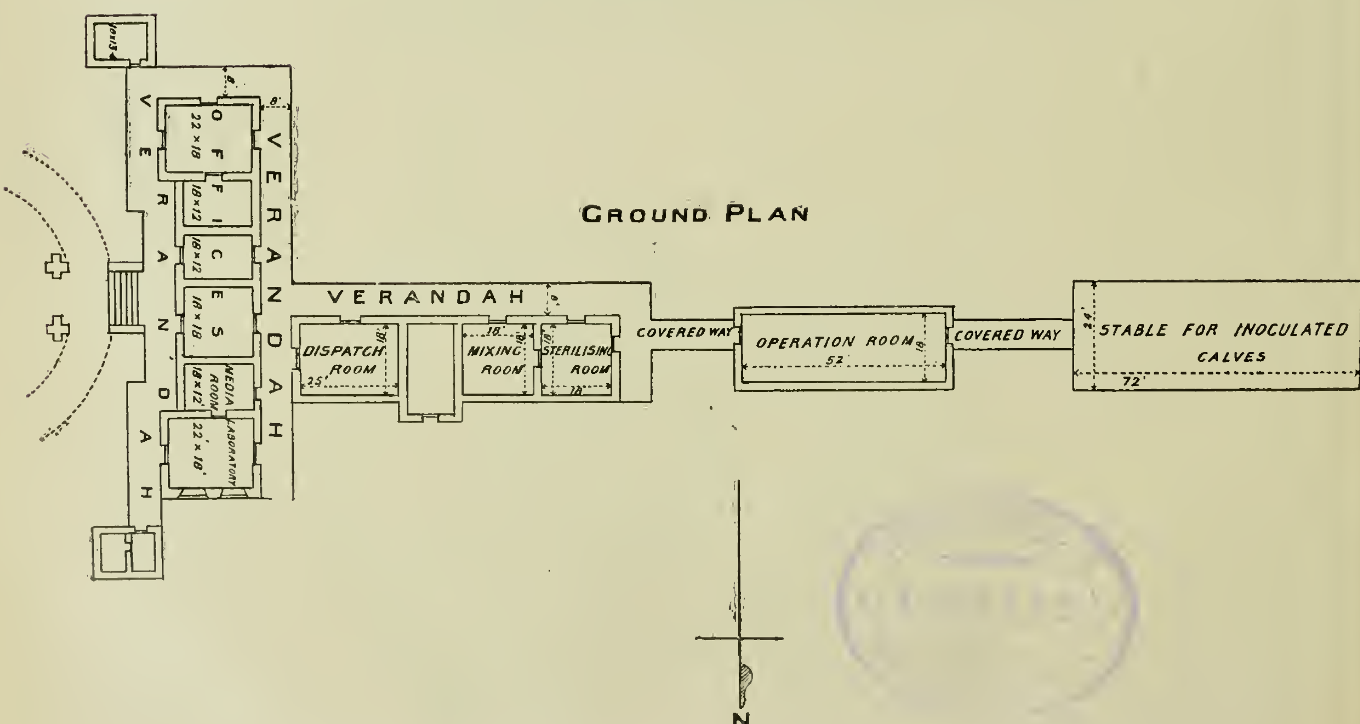


Plate IV. New Vaccine Depôt.



few cases in which some colonies of nonspore forming bacteria remain purification is effected by glycerine after storage for 7—14 days. It is seldom necessary to subject the vaccine to a further passage of chloroform vapour. It will be noticed that the practice is to pass chloroform vapour through a glycerinated emulsion, and not as Dr. Green has more recently recommended, through an emulsion of vaccine pulp in distilled water, with subsequent glycerinisation. Both methods have been tried side by side, there can be no doubt that the earlier method is by far the simpler, and, so far as the Belgaum experience goes, it is as efficient as the later method. The whole question of the relative value of glycerinated and chloroformed glycerinated vaccine for use in the tropics is of great importance, and one naturally open to two opinions. The two vaccines have been extensively tried at Belgaum, and a final opinion is not at present possible. Figures prove nothing, but it would appear that, taken as a whole, the vesicles resulting from the use of glycerinated vaccine are better in quality, both on the calf and on the child, than those resulting from the same strain of vaccine after subjection to chloroform vapour. The objection to glycerinated vaccine is that purification is very slow, especially at the low temperature requisite for maintaining the potency of vaccine during storage. It is probable that the use of chloroform vapour in the tropics will, provided proper arrangements for cold storage are made, be best confined to a partial initial purification at present effected by storing glycerinated vaccine at 15°C for 7 days.

Storage.—Corked test tubes or glass stoppered bottles are used. It is important to fill the tube or bottle as completely as possible, and to seal with carbolised paraffin. An office copy of each vaccine number is kept for laboratory purposes. Too much stress cannot be laid on the necessity for proper cold storage Dr. Blaxall and Dr. A. B. Green have proved the influence of heat on the potency of calf vaccine, and in England it is found necessary to store glycerinated vaccine at a temperature considerably below freezing point. The chief reason for this being that at higher temperatures the potency of vaccines is liable to be lost before glycerine has had time to effect purification. In Belgaum, where an ordinary ice chest has been used, this loss of potency has constantly been a great handicap. A further argument in favour of a proper cold storage room in the tropics lies in the fact that during the hot weather months many calves do not respond well to vaccination, while in those who do take the vesicles are often accelerated and the vaccine prepared is far from being of first class potency. With a proper cold storage room calves could be inoculated during the most suitable months and the prepared vaccine stored until required. In this way a supply of vaccine of first class potency could be assured all through the hot weather, a period of the year seemingly favourable for small-pox epidemics.

Despatch of Vaccine.—Experience has shewn that vaccine deteriorates very rapidly in capillary tubes, and that in glass phials it loses its potency soon after reaching the vaccinator, or even before, unless special precautions are taken. Up to the present the best results have been obtained by despatching the vaccine in glass phials, each phial having its own wooden case with a tight fitting cork. At first large phials capable of holding 20—30 doses were used, but it was found that if the vaccine in one phial was used on two or more days, the results on the second and subsequent days were much inferior to the results of the first day's work. Phials with 10 doses are now used—each vaccinator vaccinates for 3 days in each week, and receives a supply of vaccine weekly. The wooden cases are packed in a cardboard box, and surrounded with sawdust. Amber coloured glass phials are of no advantage, the coloured glass seems of poor quality, and does not readily withstand high temperatures.

Use of Vaccine.—The vaccinator is expected to use his week's supply as soon as possible. He is also instructed never to uncork the wooden cases until he has the children ready for vaccination, and to carry the corked wooden cases in a special "store box." The vaccine in a phial once opened is to be used on the spot or else thrown away.

The instrument (*vide* photo.) is a modification of Padbury's lancet It is made by Messrs. Kirloskar Bros. The spatula end has been converted into a scoop which serves for removing vaccine from the phials, as a rough measure, and also for distributing the vaccine over the scarified area.

Results.—The methods described have been in force since June last. Over 270,000 results for primary vaccinations have been received, the case and insertion success rates being 99·9 per cent and 98·1 per cent respectively. The results have been received from over 300 vaccinators distributed over the Bombay Presidency excluding Sind. It remains to be seen if equally good results can be obtained during the hot weather months. A ground plan of the new Vaccine Depôt buildings is attached—the proposed refrigerating room is not shewn as it has not yet been sanctioned.

These notes are not intended to be a complete description of calf vaccine preparation and distribution, but only of the modifications of European methods rendered necessary by adverse tropical conditions.

DISCUSSION.

Colonel Little made some remarks about the value of lanoline as a preservative of vaccine. He said lanoline had been used a great deal for this purpose in Madras. When he was in Burma they used lanoline there chiefly as a preservative and they found that glycerine did not preserve the lymph as long as lanoline. They were carriyng on experiments there when he left, and he did not know what the results were. His own experience was that lanoline was superior to glycerine. No doubt, glycerine preserved the lymph, but it was liable to be spoiled on being exposed, and one could not be sure that the vaccinator would take due precaution to preserve it from heat and exposure. Lanoline preserved the lymph better than glycerine.

Captain E. F. Gordon Tucker said: Any preservative that they could get for calf vaccine would certainly be a great improvement upon the stuff they now got. The stuff they got in little tubes from the local authorities here was most unsatisfactory. On the other hand, if they used the calf, which was supplied in Bombay, the result on the children's arms was

much too severe. That was his experience. He hoped some facilities would be given to them to get this vaccine— whether it was lanoline or glycerine, provided it was sterile.

Colonel Little then made some further observations. He said in Berars they carried on vaccination throughout the villages direct from the calf. The vaccinator vaccinated the calf, which was supplied to him by the headman of the village, and then vaccinated children from that calf. The calf was then taken to the neighbouring village or to more than one village. This system answered remarkably well and could be carried on with very little expense. The revenue authorities gave them every assistance and no charge was levied for the calf.

Captain Hutchinson in replying said: They used lanoline in Belgaum as a preservative for some years. It was undoubtedly better than glycerine as a preservative, but unfortunately it had no bactericidal property. Apparently bacteria were to be found in the vaccine as well, and they became more numerous in a fortnight or three weeks after the storage of lanoline. For that reason they had gone in for glycerine entirely and distributed the lymph in small tubes, each in a wooden case. The results of their experiments during the last nine months showed that glycerine preserved the lymph sufficiently long.

ABOUT OATMEAL CURES FOR DIABETES MELLITUS.

By Professor CARL von NOORDEN,

Head of the First Medical Clinic in Vienna (Austria).

At the Congress of the German Scientists held in the year 1902 I gave for the first time a report about oatmeal cures in the case of Diabetes mellitus. I had made the experience that many diabetic patients had borne the diet of oatmeal very well, so that we could give them great quantities of the same, without causing glycosuria, while all other carbohydrates brought on excessive sugar secretion. Indeed it was possible sometimes under the influence of oatmeal (50 grammes a day and more) to cause the sugar to disappear altogether, where the strictest diet, perfectly free from carbohydrates, did not render the urine perfectly free from sugar. It seemed even as if in such severe cases the oatmeal had a more favourable effect and was borne better than in slighter cases of diabetes. These experiences as to the effect of oatmeal were quite paradoxical, *i.e.*, they seemed to contradict all former experiences as to the influence of carbohydrates on diabetes mellitus. One must remember that 250 grammes of oatmeal contain not less than 180 grammes to 190 grammes of pure starch.

In the 6½ years since my first publication a number of communications on the subject from other authors have appeared. Most of them endorsed my opinion entirely, others differed from them. I can perfectly well understand that some of these writers arrived at unfavourable results, for firstly it is absolutely necessary at the commencement of an oatmeal cure to keep strictly to definite rules, acquired by experience, and this was not always the case with those who had bad results. And secondly I have myself pointed out from the beginning that only a small portion of diabetic patients are benefited by the oatmeal cure, while the majority are unfavourably influenced by it. He who has only to do with single cases will for this reason never be able to form a correct opinion.

Since I made a trial of the oatmeal cure for the first time in the year 1899 I have treated 2,000 cases of diabetes for weeks in my public and private clinics. In the case of 400 of these patients the oatmeal cure was applied and I am now in a position to give a definite judgment as to the practical value of the same, although we are still far from being able to offer an explanation of this enigmatical result.

I will next explain my method of procedure in the oatmeal cure :—

1. It is absolutely necessary before beginning the oatmeal cure to cleanse the urine entirely or almost entirely from sugar. This is done by restricting the patient for some days to the usual diabetes diet of absolutely no sugar and no starchy foods. If by this means they are still not free from sugar, as sometimes happens in severe cases, the patients must have two "vegetable days." The food consists on these days of the following elements :—

Tea, Coffee (without additions).
Meat broth—made from beef, veal, mutton or chicken.
Five whole eggs (hens' eggs) and five yolks of eggs.
Fresh vegetables as spinach, green salad, cucumbers, tomatoes, cauliflower, asparagus, sauerkraut, etc.
Butter, bacon, marrow of bone or oil.
Lemon, vinegar.
Mineral waters.
½ bottle of claret, 1 or 2 small glasses of cognac or whiskey.

Only in the severest cases then small quantities of sugar remain in the urine. Sometimes the Aceton-bodies increase.

2. The oat cure consists in the daily administration of 250 to 300 grammes of oatmeal, best given in the form of gruel or porridge, every 2 hours, 200 to 300 grs. of butter, and about 100 grs. of vegetable proteid or 8 eggs may be taken in addition. Most of the patients prefer the eggs. Nothing else is allowed except black coffee or tea, lemon juice, good old wine or a little brandy or whisky. In many cases you will see, that these large quantities of oatmeal agree excellently with the patient and that either no sugar at all or only 20 to 30 grs. can be found in the urine; this shows that by far the largest quantity of carbohydrates of the oatmeal have been assimilated.

3. After the 3 oatmeal-days it is absolutely necessary to let 2 vegetable days follow, as I described under No. 2, should the urine not have become sugar-free during the oatmeal-days; it will become so then nearly in all cases.

4. It is exceedingly useful then to let again 3 oatmeal-days follow at once, upon which 2 vegetable days should succeed.

5. Now only may one begin to let other foods be added slowly to the foods which are allowed on the vegetable-days. One may best try with an addition of fish, 200 to 300 grammes, and only when the proof has been given that fish does not let sugar reappear in the urine, some meat may be taken. In severe cases, however, this should never be more than 200 grammes weighed cooked. Later on, cheese and cream are allowed. Now the patient has again arrived at a diet, which is called the ordinary strict diabetic-diet. One will notice that he now with this diet eliminates much less sugar, and that the quantities of aceton are much smaller than they were before the oatmeal cure began. It is then allowed to try small quantities of other carbohydrates (bread, potatoes and others). In the following table I give an example, from which you will be able to see the daily foods and the daily elimination of sugar and of aceton :—

Day.	Food.	Sugar—Grammes in the urine of a day.	Aceton—Grammes in the urine of a day.	Weight of the body.
1	Strict diet and 75 grammes of bread...	100·2	1·2	58·2 kg.
2	Do. do. do. ...	98·7	1·5	......
3	Strict diet without bread ...	56·4	1·8	......
4	Do. do. ...	47·6	2·9	......
5	Do. do. ...	46·9	1·4	......
6	Vegetable day	19·7	1·6	......
7	Do.	10·2	1·9	......
8	Oatmeal day (250 grammes of oatmeal)...	24·3	0·8	......
9	Do. do. ...	19·3	0·8	......
10	Do. do. ...	12·7	0·6	......
11	Vegetable day	......	0·5	......
12	Do.	......	0·3	......
13	Oatmeal day (250 grammes of oatmeal)...	......	0·3	......
14	Do. do. ...	......	0·1	......
15	Do. do. ...	......	0·06	......
16	Vegetable day	......	0·08	......
17	Do.	......	0·07	......
18	Vegetable day and 200 grammes of fish...	......	0·08	......
19	Do. do. ...	......	0·1	......
20	Vegetable day, 200 grammes of fish, 100 grammes of meat ...	......	0·1	......
21	Do. do. ...	......	0·11	......
22	Ordinary strict diet	......	0·09	... .
23	Do. do.	......	0·08	......
24	Strict diet and 60 grammes of potatoes...	......	0·09	......
25	Do. do. ...	......	0·11	61·4 kg.

This shows you :

The patient suffered from a severe form of glycosuria which did not disappear although carbohydrates were strictly withheld (day 3 to 7).

During the first oatmeal cure the patient did not become quite free from sugar, which even increased a little (day 8-10).

The following vegetable days resulted at once in a urine without sugar which remained so during the succeeding three oatmeal days.

For some time thereafter a diet was tolerated which previously had produced severe glycosuria (compare the days 20 to 23 with the days 3 to 5).

It was even possible to give a small quantity of potatoes (day 24 and 25). This case could no longer be counted as of the severe diabetic cases, one of which it had formerly been.

The aceton diminished and the body weight increased.

Practical experiences.—My practical experiences are the following :—

1. Amongst about 400 patients with whom I tried the oatmeal cure I gained excellent results with 28 per cent., that is such results as can be compared with the above example.

2. The best results were gained with children, young men and women and grown up people to about 40 years old. For older diabetics the oatmeal cure is not so suitable although I had some good results with people between 50 and 70 years of age.

3. By far the best results were obtained in medium cases. Very severe and quite slight ones are not so suitable for this cure.

4. Diabetic patients with nephritis may on no account be exposed to the oatmeal treatment, because in most œdema results which only disappears slowly.

5. Often the oatmeal produces strong diarrhœa. This can be prevented by ordering tincture of opium during the cure, which will make the diarrhœa disappear at once (5 times a days 5 drops of tincture of opium).

6. Such patients who suffer from bad secretion of the pancreatic gland may not undergo the oatmeal treatment. They would acquire severe fatty diarrhœa (Steatorrhœa), which leaves them very weakened.

7. The good results of the cure will always fail to come as soon as other carbohydrates are added to the oatmeal, and it is also disadvantageous to add meat or extract of meat or meat-broth or casein, plasmon or other foods of this kind.

8. Should diabetic coma threaten, there cannot be found a better means to avert the danger of the auto-intoxication than the oatmeal cure. In such cases it is most important to cause the resorption and assimilation of as many carbohydrates as possible. Next to this of course alkalines must be supplied.

9. The oatmeal treatment cannot cure Diabetes mellitus, but it can considerably diminish its danger. It is of the greatest importance that from time to time the patients should assimilate large quantities of carbohydrates. Thereby the danger of acid poisoning is averted. For this reason I prescribe, in such cases, in which the treatment has turned out well, a repitition of the oatmeal cure 4 or 5 times a year. The cure always takes one week as follows, that is,

2 vegetable days,
3 oatmeal days,
2 vegetable days.

10. One often has technical difficulties in accomplishing the cure and it is nearly always impossible to

achieve good results, if the patient undergoes the treatment for the first time in his own home. I therefore always insist upon his undergoing the treatment for the first time in a hospital or in a sanatorium. As soon as once he has learned how to behave during the oatmeal-days, the later trials can easily be undergone at home.

EXPLANATION OF THE RESULT OF THE OATMEAL-CURE.

1. It has been said that the results of the oatmeal-cure depend upon the diminution of the proteids ; one knows that diabetics often stand more carbohydrates when taking only few proteids than they do when taking many proteids. But this interpretation is wrong. The results of the cure are the same if 100 gr. of vegetable proteids or 8 eggs are added—even more eggs could be allowed, but meat would disagree.

2. It has been said that glycosuria does not result from oatmeal because the starch of the oatmeal ferments in the intestinal canal and that consequently only fatty acids and no carbohydrates are resorbed. But this objection is also wrong ; for the composition of the fæces is in most cases quite normal ; moreover, the decrease of aceton proves with certainty the resorption and assimilation of carbohydrates.

3. I previously thought and taught that the particular nature of the amylum, which oatmeal contains, was the cause of its good assimilation. It is known that some carbohydrates agree better with diabetic persons than others, such as Lævulose, which is better tolerated than ordinary sugar and all the other sweetening agents. We have tried to prepare the starch of the oatmeal quite pure, and to compare its effect upon the diabetic patient with the starches of various other substances (from wheat, rye, potatoes, etc.) But the pure starch of oats acts just as unfavourably upon the glycosuria as other starch does. However, it is sure that the starch, when prepared pure, undergoes certain alterations in its chemical constitution. Possible it is, that the starch of oats, in its original constitution, possesses quite different qualities from the pure oat-starch and that indeed it agrees better with the diabetic than other starches.

4. Latterly our attention is directed to the fats of the oat. We found that the alcoholic and ætheric extract of the oat contains substances of very great toxic power. If you give to a small dog a subcutaneous injection of 1 gramme of concentrated oat-extract, which contains the fats and the lipoids, the animal dies paralyzed in 24 hours.

We caused artificial glycosuria in dogs by injection of adrenalin. When, at the same time, we injected a small quantity of oat-extract, no glycosuria arose. As there is no doubt that the adrenalin diminishes the internal secretion of the pancreatic gland, the probability arises, that the oat-extract has the opposite effect *i.e.* that the extract is a stimulus for the pancreatic secretion.

After extirpation of the pancreatic gland in animals, the oatmeal treatment has a very bad effect and also the oat-extract does not diminish the glycosuria. Also this seems to prove that the oat-extract only acts by influencing the internal pancreatic secretion in a direct and specific manner.

You must acknowledge, that these experiments give a good prospect for the treatment of diabetes in men. Until now we did not dare to administer the oat extract in cases of diabetes, because all the extracts which we prepared were eminently poisonous, but of course the experiments are continued. We hope to gain such extracts of oat, which are not so poisonous but which produce the wished for good effect upon glycosuria.

As we see things to-day, we presume that the astonishing effect of the oat-meal treatment is due to the circumstance that with the oat we introduce into the body small amounts of a substance which acts by stimulating the internal secretion of the pancreatic gland. Why this good effect is only met with in certain cases and missed in others, we cannot yet tell.

THE USE OF APPENDICOSTOMY IN THE TREATMENT OF INTRACTABLE ULCERATION OF THE COLON.

By CAPT. E. F. GORDON TUCKER, I.M.S.

In September 1906 I read a paper before the Bombay Medical and Physical Society on "Appendicostomy, the surgical treatment of chronic dysentery," and produced my patient who had been operated on at my request by Professor Quicke, I.M.S. This was, I believe, the first instance in which this operation had been performed in India for this common and intractable condition. Further experience has left no doubt in my mind that we have here a most valuable method of dealing directly with general and intractable ulceration of the mucous membrane of the large bowel, and with the serious condition of inflammation, induration, and friability which affects the muscular portion of its coat.

I sincerely hope that we may elicit some information of the experience of this method of treatment from those who are attending this Congress.

This operation was first performed by Weir of New York on a young man with persistent chronic diarrhœa. He was about to perform a cæcostomy, but the appendix came so conveniently into view, that he completed the operation with an appendicostomy, and the result of the case was very good.

Since this the operation has been performed by a good many surgeons in England and America, and those who have had most experience speak highly of the results afforded. My attention was first called to it through a

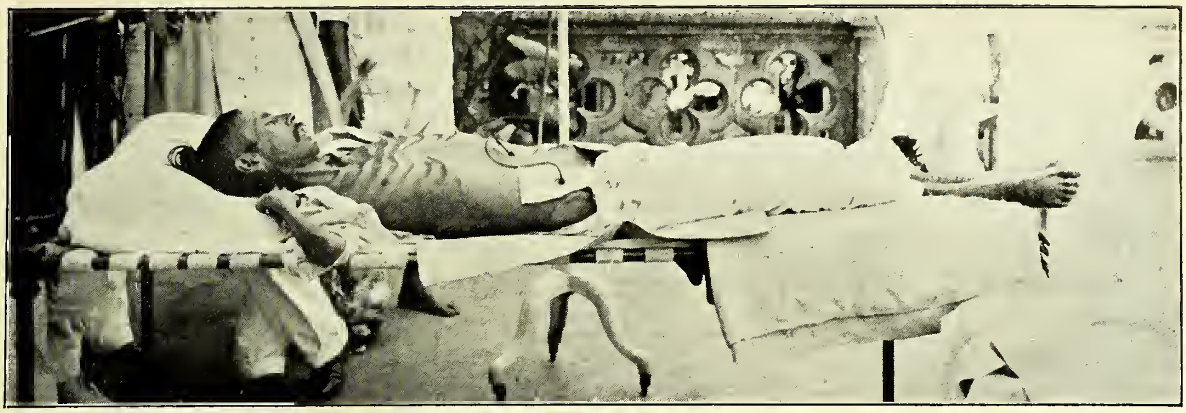


Fig. 1.
Method of irrigating the Colon *via* the Appendix.

Fig. 2.
Dysenteric Ulcers after eight days' irrigation showing clean bases.

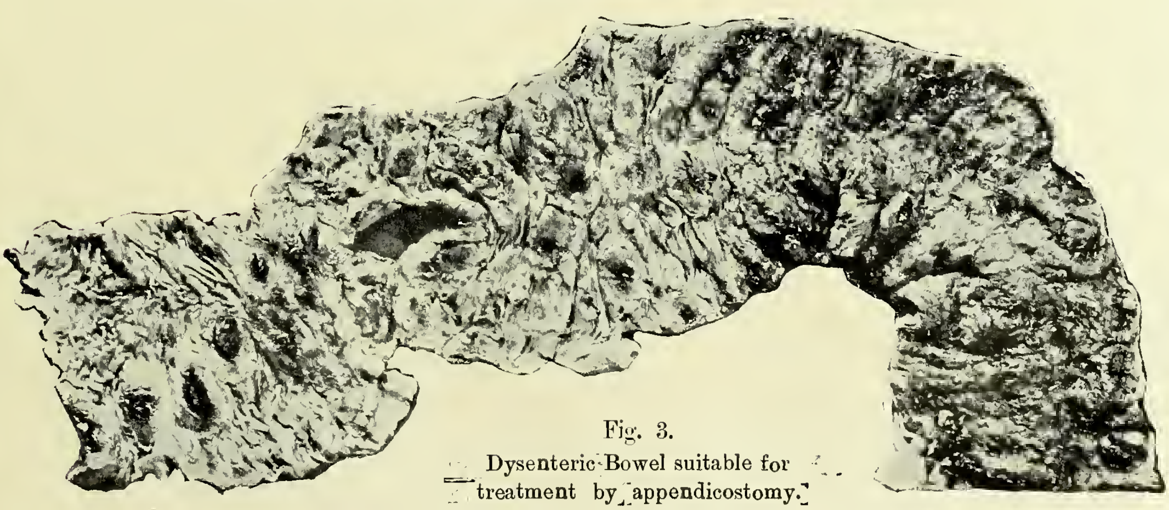


Fig. 3.
Dysenteric Bowel suitable for treatment by appendicostomy.

paper by Mr. C. B. Keetley in the British Medical Journal of October 7th, 1905, in which the writer states that actual experience has demonstrated the following indications for performing the operation:—

1. Mucous Colitis.
2. Dysentery (that is, amœbic colitis).
3. Obstinate chronic constipation.
4. Ileo-caecal Intussusception,—to prevent recurrence, to prevent collapse, and to treat hæmorrhage or inflammation.
5. Syphilitic ulceration of the colon, with hæmorrhages.

He describes the operation as follows. Make an oblique incision at the outer edge of the rectus muscle near McBurney's point, and in a line with the fibres of the external oblique, divide the under-lying aponeurosis with its adherent muscular fibres, and seize and open the peritoneum. The incision should be just long enough to admit two fingers. Put in two fingers and bring out the appendix if free, as it usually is. If it is not free bring out the caecum and proceed as in an ordinary appendicectomy. Pull home the base of the appendix to the parietal peritoneum. The meso-appendix unless very wide and short, should not be cut.

"The catgut sutures used to narrow the holes in the parietal peritoneum should be used also to anchor the meso-appendix, after being knotted; and the second knot should be easy, so as not to strangle any vessel in the meso-appendix. One or two buried sutures may be required to narrow the aponeurotic openings round the appendix, and a silkworm gut suture or two to narrow the skin wound. . . . A free incision must be carefully closed according to rule, but the two silkworm gut sutures should fix the seromuscular coats of the appendix to the skin, and not be drawn needlessly tight."

He recommends that the appendix should not be opened until the following day, the snipping off of the end of the little tube being absolutely painless. The organ can of course be opened at the conclusion of the original operation, and for the majority of the severe cases of dysentery for which I have performed it, I have found it convenient to wash out the bowel at once, sealing the wound with collodion before pushing the catheter down the appendix.

The cases we get in India which are suitable for this method are those instances of a chronic intractable dysentery which have been allowed through neglect or privation to reach such a stage that all efforts to improve them by diet and medication are found to be absolutely without effect in diminishing the number of the stools, the amount of sloughed-off mucous membrane passed therein, or in altering in the slightest degree the extreme emaciation which is characteristic of these patients.

Such cases are not common, for most cases of Indian dysentery respond to scientific treatment by ipecacuanha and careful dieting. However, there is a large residuum of Hospital patients who come for treatment when they have reached this stage; and we are likely to find this type in men who have returned from a trying campaign. A larger number of these chronic cases are seen at the Sir Jamsetjee Jeejeebhoy Hospital and I have performed many autopsies on them at that institution. Not a few of these were for cases of sudden rupture of the large bowel, and the consequent admission of the patient in a state of collapse, a condition which is absolutely hopeless. They never rally, and even if they did it would be practically an impossibility to suture the inflamed and indurated bowel wall.

The sort of patient I refer to is a man who gives a history of dysentery extending over six or eight months without any intermission of good health, or who has been suffering off and on for two or three years. His emaciation and anæmia are profound. The pulse is small and thready, and the heart sounds are feeble. The belly is generally rigid, and there is marked tenderness along the line of the large bowel.

The stools are twelve to six in number during the twenty-four hours. They are passed with a good deal of abdominal pain, and are very offensive. Desire for food may be considerable, but when taken is liable to provoke an early action of the bowel and further abdominal distress.

The stools are somewhat large, almost or quite liquid, more or less feculent, containing a varying amount of mucus, some blood; and pieces of sloughed-off mucous membrane, perhaps an inch square. In a few cases these sloughs are minute and can only be detected by washing.

These patients are obviously the worst of subjects for even the smallest abdominal operation, and consequently, for us in India, the operation of appendicostomy is certainly not a trivial one.

The condition of the bowel is as follows. The mucous membrane from the caecum to the rectum shows innumerable large serpiginous, round, or oval ulcers; the margins ragged, the bases covered with long tags of the partially sloughed-off inner coat. What remains of the mucous membrane is acutely inflamed.

The muscular coat is indurated and friable. Microscopical sections show intense small-celled-exudation among the muscle fibres. The serous coat is sometimes almost claret-coloured; it is always injected. The bowel may be puckered from adhesions within the folds of adjoining sacculi; and lastly we not infrequently find actual fæcal abscesses shut off within acutely inflamed adhesions, most often in the neighbourhood of the upper portion of the descending colon.

The result of this serious pathological condition must be that there is continual absorption of poisonous material from the whole of the ulcerated surface of the pus containing tube; peristalsis of the indurated muscular coat must be of the most irregular character; and finally the large intestine cannot function. One of the chief functions of the large bowel is to absorb water, and this is done so quickly in health that the fluid material coming through the ileo-cæcal valve has been converted into solid masses by the time it passes the hepatic flexure.

It is this absence of the absorption of fluid from the large bowel in chronic sloughing colitis which, I think, explains the dried-up emaciated appearance of the patient. After two or three irrigations of the large bowel *via* the appendix the facial aspect of the person changes remarkably for the better. And he also loses the pasty complexion characteristic of chronic septic processes as soon as the surfaces of the ulcers have been completely washed over.

I have used solutions of protargol of glycothymoline, and boric acid ; it does not appear that it matters much what is used so long as the fluid is warm and copious. It is obvious that by this treatment we are washing the ulcerated surface uniformly with an antiseptic or astringent fluid in the normal direction of the intestinal contents, and without raising the internal pressure to a dangerous degree. The following cases illustrate the effects of this treatment, the possible mortality of the operation, and the accidents which may happen to the appendix.

Case. I.—D. B., aged about thirty, had had dysentery off and on for more than two years, symptoms having been continuous and distressing for the four months preceding admission into the J. J. Hospital in 1906. Emaciation was profound, there was much abdominal pain, there were from six to twelve stools a day all containing much muco-pus and sloughs. The spleen was considerably enlarged and hard. The lungs were perfectly clear.

During February and March he remained under me, and made no improvement at all under a varied medical treatment Appendicostomy was performed by Professor Quicke, I.M.S., on April 9th. There was no shock or pain referable to the operation.

The appendix was opened on the fourth day after this, and seventy-three ounces of a solution of 1 in 400 of protargol introduced through a No. 4 catheter. By the following day there was already a change for the better. He had passed a large fluid motion containing sloughed-off portions of mucous membrane and semi-digested food. There were four more stools of a similar character on this day, when sixty-three ounces of the same solution were introduced. On the third day a similar quantity was used and the stools had dropped to two, there being a decided tendency for the sloughs to disappear. By the fifth day the only evacuation was caused by the injection, which was passed almost at once, practically unchanged, and containing no obvious slough. Matters went on thus without trouble, the amount of injection being gradually reduced. Although his digestive powers remained deficient all the abdominal distress disappeared and he gradually put on weight. There was never any leakage from the stump of the appendix even during the largest injections. He refused to have any operation to close the stump of the appendix and in some ten weeks left the hospital a different man. The photograph shows the method of irrigating the colon, and his condition of emaciation a short time after his return to the medical wards.

For the successful treatment of this desperate case we were indebted to the kindness and dexterity of Professor Quicke. The following cases were operated on by myself, and under conditions of asepsis and nursing rather different from that which obtains in the Sir Jamsetjee Jeejeebhoy Hospital.

Case II.—M. K., a beggar, came under my care in the Dharwar Civil Hospital on December 7th, 1906, suffering from severe dysentery. The illness had lasted for an indefinite time ; men of the class are not at all reliable in their statements about dates. Symptoms had been very severe for ten days, and shortly before admission he was passing an enormous number of stools a day, containing blood and slime. He was very emaciated and weak and the abdomen tender. The sloughs were numerous and fairly large. Treatment by ipecacuanha on proper principles during four days was absolutely without effect, and as he was obviously going to the bad rather rapidly appendicostomy was done on the 11th.

While bringing the appendix out of the wound, the lower portion of the large bowel was felt to be considerably thickened, and the cæcum unusually adherent to the tissue behind it. The appendix was also extremely curved upon itself, and the meso-appendix had to be partially cut to allow the end of the little tube to be straightened out. The appendix was fixed in position, about three-quarters of an inch of it remaining outside the wound.

There was considerable collapse after the operation, but the patient revived after stimulating hypodermic injections had been given.

The dressings were removed forty-eight hours after the operation, and the tip of the appendix snipped off and rather more than a pint of warm boric lotion passed in through a No. 4 olive-headed catheter.

On the same day and during the following night he passed twelve stools containing a little blood, much mucus and many small sloughs. On the 14th the bowel was irrigated *via* the appendix with one pint of a solution of glycothymoline. During the next twenty-four hours he passed seven stools of practically the same character except that fæcal matter was more in evidence. On the 15th the bowel was irrigated with two pints of glycothymoline solution ; the injection was passed per anum shortly afterwards. During the next twenty-four hours the number of evacuations had decreased to nine semi-solid or almost liquid, and fæcal in character. All sloughs had disappeared. He was feeling much better. There was a little suppuration about one of the deep sutures. Two superficial stitches were removed and the cavity cleaned and packed with gauze. There were five motions which now began to take the form of the bowel. On the 17th one pint of warm boric lotion was passed in. On the 18th a pint and a half of glycothymoline lotion (one dr. to the pint) was passed in ; five semi-solid motions. On the 19th six stools with a little mucus. On the 21st there were two formed motions, and the bowel was irrigated for the last time with half a pint of boric lotion. Subsequently there was only one, and on a few occasions

two, normal motions a day. Some slight delay was caused by the superficial suppuration, but the subsequent course was uneventful, the wound being closed over the appendix on the 14th of January. A few weeks after his discharge he came up to the hospital to show himself, and I did not recognise him as the emaciated depressed patient had changed into a fat and jovial individual.

Case III.—Severe Chronic Dysentery. Appenidcostomy. Death from Shock.—S. M., a blind beggar, male, aged thirty-eight, was admitted into the Dharwar Civil Hospital on December 20th, 1906. He had had symptoms of dysentery for six months. For six days he was treated with ipecacuanha, strict dieting and other remedies, with the view of relieving the almost continuous evacuations and abdominal pain. He was very emaciated, and intensely anæmic and the lower eyelids and ankles were puffy and œdematous. There was no albumen in the urine at any time, the specific gravity was 1010. He had been blind from infancy.

As medication had no effect in relieving his desperate condition, he was operated on on December 27th. He had a preliminary hypodermic injection of digitalin and strychnine. The operation was a very easy one and soon completed. The appendix was long, and not curved at all. It was rapidly fixed in position without any manipulations within the abdomen having been necessary, and without any tension on the tube itself.

The patient was very much collapsed after this comparatively simple operation. He was of course in a very low state and the heart had been very weak from his admission. There was some free acetic fluid in the abdomen. He never rallied in spite of careful treatment and died the next morning.

I think the chloroform had something to do with the man's death; the operation was the easiest possible. Nevertheless the cases operated on for this condition are in such a desperate plight that some mortality must be expected

Case IV.—Chronic Dysentery. Appendicostomy. Death on the 10th day from Pneumonia.—M. R., aged thirty, male, a wandering beggar. Had been ill with very severe dysentery for two months, the disease dating from an acute attack at that date. He was passing on admission ten or twelve stools a day, containing an unusually large quantity of blood, mucus and slime. The evacuations were of a greenish colour. Emaciation profound. Abdominal pain marked and constant. Operation on the 26th January 1906. About $1\frac{1}{4}$ inch of the appendix was fixed outside the abdominal wound, which was sealed with collodion. The end of the tube was snipped off and a pint of a 2 per cent. solution of protargol was passed in. He had five motions on the following day, and five on the 28th, all containing mucus and sloughs. On this day his curiosity prompted him to have a look at the wound, and manipulate the part. As the result of his movements and interference the appendix slipped under the skin, and this was picked out and sewn in position on the 29th. On this date the number of stools having increased, two pints of protargol solution were injected. On the 31st there were six stools, some of which appeared to be becoming fæculent. A pint and a half of protargol solution was injected. One stool on this date, the characters of which showed considerable improvement. The temperature went up in the evening to 101° and he complained of cough. The movement of the right chest was impeded. Half a pint of protargol solution injected. On the 2nd and 3rd there was only one stool each day, which had become almost natural but inclined to be loose. On the evening of the 3rd, the distressful breathing became more marked, the pulse being very weak. He died from heart failure on the morning of the 4th.

Post-mortem.—The whole of the right pleural cavity was obliterated by old and extremely dense adhesions which accounted for the deficient movement of this side. There were also several broad adhesions in the left pleura. The heart was flabby and the ventricular walls extremely thin, which accounted for the poor fight he was able to make against the pneumonic process.

The whole of the large bowel was greatly ulcerated from the cæcum to the rectum. I show a photograph of a portion of it, from which its condition can be judged. The specimen is in the Museum of the Grant Medical College. There are no shreds of slough attached to any of these ulcers, they have all been washed away by the injections. Moreover many of the ulcers in the cæcum and ascending colon already show signs of healing in from the edges. In fine, all the ulcers were clean, and had been put in the way of healing, and within the lumen of the bowel there was none of that foul puriform grumous fluid which is always abundant in fatal cases of chronic dysentery.

The unfortunate result in this case cannot be referred to the operation, but to the neglect of the ward servants in not protecting him properly from the cold during the bitter nights we were experiencing at the time.

The right lower lobe was in a condition of red hepatization.

Case V.—This case was operated on in Sholapur during March last. The notes have been lost, but the man was one of the most troublesome cases I have seen on account of his obstinacy and stupidity. The case was one of long standing chronic dysentery, and the appendix was washed out at the time of the operation, and daily with good results. The man however took off all his dressings on the first day, and caused suppuration in the stitches. We were however able to wash out the bowel daily, and with good results. Convalescence as regards complete restoration to healthy functioning of the bowel was delayed through his stealing the other patients' food, and that of the least digestible kind.

These five cases are hardly sufficient to allow us to draw dogmatic conclusions. Nevertheless they do show that very good results are to be expected. Having seen for myself the immense change for the better which takes place almost immediately in these emaciated persons after irrigation is begun, and having had an opportunity of noting the condition of the sloughing ulcers after only eight days of the treatment, I think I

may be allowed to claim that the operation of appendicostomy deserves consideration in the treatment of intractable dysentery.

The wit of man has not yet invented an apparatus which prevents the subject of a colostomy from being a nuisance to himself and everyone else. There is absolutely no leakage through the appendix when fixed in position. The two operations are not comparable as regards comfort to the patient or results in treatment. And finally there is retained the power of absorbing water from the large bowel, which is one of the functions of this important viscus.

DISCUSSION.

Major R. Heard, I.M.S., said: Captain Gordon Tucker agrees with Mr Keetley that the snipping off of the appendix, subsequent to the primary operation, is painless. I think that this is not invariably the case. In a case of mine in an European lady, considerable pain was complained of. The pain was referred towards the gallbladder and epigastrium; and for a few days after the operation, any manipulation of the stump caused discomfort referred in that direction. I think this interesting with reference to the prevalent idea that the position of the appendix, in cases of appendicitis, may be indicated, before operation, by the direction in which the pain is referred. I would suggest the advisability of clamping the appendix, with a Cornat's clamp, at the time of the operation, in this way sealing it until the irrigation is to be begun.

As regards the use of fine pointed stiff catheters for irrigation, I consider that their use, in cases like those referred to by Captain Gordon Tucker, is not free from risk of perforating the bowel. The appendix is capable of considerable dilatation, and will admit large sizes of soft rubber catheters, if gradually dilated with low numbers of Hegar's dilators.

I would advocate the more frequent use of appendicostomy in the earlier stages of mucous colitis. I believe that these cases not infrequently develop an appendicitis, and the appendix may not then be in so favourable a condition for irrigation purposes. I may mention a case of chronic mucous colitis, that had received treatment at Carlsbad and other places, which eventually developed into appendicitis with perforation as the base of the appendix, the colitis continuing after the operation. In this case, had an appendicostomy been performed early, the patient would probably have been cured of his colitis and would have been saved the risks and discomfort of the appendicitis.

So far no injurious after effects of the operation, *e.g.*, ventral hernia, have been reported.

THE PREVENTION AND TREATMENT OF DYSENTERY IN JAILS.

By Lieut.-Colonel W. J. BUCHANAN, B.A., M.D., D.P.H., I.M.S.,

Inspector-General of Prisons, Bengal.

The subject of the prevention and the treatment of dysentery is one of great importance in the jails of the two Bengals. It is probably a more common disease in Bengal than in other parts of India, so much so that Norman Chevers, an acute observer, many years ago applied the term *Morbus Bengalensis* to the chronic ulceration of the intestinal tract from which so many natives of Bengal die.

I do not propose to burden this paper by statistical tables, but the opposite one, compiled from the Administration Reports of the Bengal Jail Department, shows at once the incidence and fatality of the group of diseases clinically known as dysentery, calculated on the daily average strength of the prisoners for the past 20 years in Bengal.

Year.	Dysentery. Ratio per mille of average strength.		Total death-rate.
	Admissions.	Deaths.	All causes.
1888 ...	397	15	44·7
1889 ...	416	16	45·7
1890 ...	314	11	32·2
1891 ...	292	9	30·9
1892 ...	329	11	43·7
1893 ...	272	12	32·3
1894 ...	379	19	47·1
1895 ...	364	9	27·4
1896 ...	280	5	28·6
1897 ...	232	10	34·4
1898 ...	200	5	22·5
1899 ..	221	6	23·4
1900 ...	304	10	40·3
1901 ..	251	8	27·5
1902 ...	217	6	25·4
1903 ...	207	5	23·5
1904 ...	231	5	19·8
1905 ...	203	6	25·3
1906 ...	196	6	23·7
1907 ...	145	3	17·5
1908 ...	......	... ..	......

This table shows a steady and progressive fall in the incidence rate from close on 400 per mille 20 years ago to only 145 in 1907, and a even more notable fall in the death-rate per mille from 15 or 16 to under 5, the average of the past few years. The case-death-rate has never been high, but has fallen in the same period from 5 per cent. to about 2 or 3 per cent. only.

Before going further something must be said of the types or varieties of dysentery met with in Bengal jails. The most complete study of dysentery from the bacteriological side is that of Capt. W. H. C. Forster, I.M.S., who was put on special duty, by the Sanitary Commissioner with the Government of India, to study the subject of dysentery. On his coming to Bengal I was able to give him ample opportunities for his work in the Midnapore

* *Vide, Indian Medical Gazette*, 190, p. 2017 and 375; also *Indian Medical Gazette*, 1908, April, p. 143.

Central Jail, which has always been notorious for its high death-rate from dysentery.

According to Captain Forster the types of jail dysentery are several, and in different cases he has been able to isolate the bacillus of Shiga, the bacillus of Flexner, and the "Y" bacillus of Hiss.

In a few cases he has found what is called "amœbic dysentery" and more frequently he has found cases of chronic dysentery in which amœbæ were merely present.

The majority of cases of dysentery are, however, bacillary, and chiefly due to the bacillus of Shiga. Milder cases are often due to the bacillus of Flexner, but it is of importance to remember that, in Forster's opinion, the majority of the cases belong to the serious type of the disease caused by the bacillus of Shiga.

As this paper is neither clinical nor pathological I need not further enter into this part of the subject.

Dysentery is in Bengal an autumnal disease ; it is generally at its lowest in the dry and hot weather and reaches its highest degree of prevalence in the rainy season and later months of autumn.

The Prevention of Dysentery.

The successful prevention of dysentery must depend upon an accurate knowledge of its etiology and method of spread.

In typhoid the view has recently been taken that it is the sick or convalescing patient that is the danger, the "bacillus-carrier," and Capt. Forster has brilliantly applied this theory to dysentery.

We have therefore been endeavouring to fight dysentery in Bengal jails on these lines. The bacillus of Shiga or other allied bacilli are the causes. These organisms are shed by the convalescing or sick "carrier," and reach the intestinal tract of other persons in many ways.

I am however firmly convinced that the predisposing causes are of great importance, and they have the advantage that they are, to a considerable extent, controllable. Moreover, in considering such a disease in a jail, asylum or school we must remember that a very considerable number of the inmates bring the disease with them from outside, and are therefore actual or potential "bacillus-carriers" from the moment of their admission.

Among the predisposing causes must be counted the disturbance of the digestive tract caused by unsuitable food, or badly cooked food. The danger of badly cooked food was forcibly impressed upon me some 17 years ago in Midnapore Jail, where, after a violent cyclone had wrecked the kitchen, the prisoners' food that evening and the next morning was issued in a raw, half-cooked state and there was within the next few days a sudden outburst of dysentery and diarrhœa, 125 patients having been admitted to hospital within a couple of days. On many other occasions seeing a rise in the number of dysentery cases coming to hospital I have directed attention to the cooking and almost always found something wrong. I am therefore firmly convinced that good cooking and well prepared clean food are important measures in the prevention of dysentery. Other predisposing causes are less direct, for example, previous illness, malaria, &c. Food, however, I am convinced, is more important than water. It is a commonplace of hygiene to put down bad water as a cause of dysentery and certain specific cases are always quoted. I have long held the following view (and it applies largely to typhoid also), which is that water if specifically polluted will carry the disease and will account for a sudden outburst of dysentery or of typhoid, but such outburst will be short-lived and will cease or greatly lessen on changing the water or on destroying the virus by boiling, &c., but the water-supply will not explain the persistence of a few cases of dysentery or of typhoid ; and the supply of a pure water will not get rid of these diseases, and that even where the greatest care is taken of the water. Even where it is carefully filtered in a Pasteur Filter installation and distributed in pipes dysentery may still prevail.

The water-borne theory of typhoid conveyance has long been known to have broken down in India and I have long come to the conclusion that elaborate care taken of the water in jails is not the cause of the diminished incidence of dysentery, and that it has prevailed in jails with a water-supply above suspicion and has not prevailed in jails and at times when the Chemical Examiner could only classify the water as "suspicious" or at best "usable." It is very probable that the dysentery bacilli soon die in water.

Another factor in the spread of dysentery in a jail or an asylum is by means of soiled clothing and bedding. Captain Forster's work at Midnapore shows that the Shiga bacillus has a short life outside the human body, and on clothing and on sheets the bacilli have been killed by exposure to the sun in a couple of hours. This is a good scientific authority for the practice common in jails of spreading out blankets and clothing in the sun for a few hours weekly or oftener, but this does not disprove the danger of soiled or contaminated clothing being passed on from one prisoner to another whether in hospital or out of hospital. Clothing slightly soiled by excreta and folded up may well keep the germ alive sufficiently long to infect the new wearer of the clothes This shows the necessity and importance of the boilers and wringers which we now have in every jail for the immediate and frequent disinfecting or washing of all prisoners' clothing and bedding and of the great need there is to see that careless or ignorant jailors or warders do not issue to new-comers clothing that has not been washed and thoroughly cleaned.

Once we get hold of the view that it is the convalescing or sick dysentery patient that is the danger and that for several weeks after apparent recovery he may be, and probably is still shedding the bacilli in his stools it is not difficult to suggest means for prevention. The latrine, for example, may become an important factor in the spread of dysentery, and the use of the left-hand by natives of India for ablution is also an obvious source of infection and reinfection. The free use of dry earth by each prisoner is one safeguard, the burning of sulphur or cowdung to keep off flies is another precaution, as also is the use of kerosine in the lime-wash in latrines

The proximity of cowsheds and cattle to a latrine is clearly undesirable, as it is very difficult to keep a byre free from flies. The use of a *lota* or other vessel for ablution as well as for drinking is obviously objectionable, and it is not difficult in latrines to supply special ablution vessels, kept only for these purposes and washed by the sweeper-gang after the latrine parade is over. Here I may also mention the importance of not hurrying over the latrine parades. In Bengal we have a sufficient number of latrine seats to permit to every man being allowed five minutes and the whole parade is over in half an hour (*i.e.*, 1 latrine seat for every 6 prisoners). Objection has been taken by laymen to a "latrine parade," but in the first place prisoners are certainly not forbidden to use them at other times and secondly it is sound physiology to accustom the prisoner to regularly evacuate their bowels at fixed times. The practice of taking notice of all prisoners who use the latrine at night is a useful one, if carefully used, as it enables the Hospital Assistant to catch many cases in the very earliest stage.

I need hardly go into further details, the main point is to recognise the principle that the sick or convalescing dysentery patient is himself the danger to others, and he should be looked after, especially as long as he is shedding bacilli in his excreta. Just as we are accustomed to look after and isolate a convalescing small-pox or scarlatina patient while they are shedding the germs from the skin eruption.

I do not say that it is easy, even in a jail, to carry out a full prophylaxis. Difficulties as to safe custody, work and discipline arise, but it is well worth persevering in the strict isolation of these "bacillus-carriers," even at a temporary loss and with considerable difficulty. This method will certainly soon reduce the number and the more thoroughly the method is persevered in the more certain is the reduction in number and consequently the less the difficulty.

The question of the new-comer remains.

The population of a jail is eminently a floating one and about as many come in as pass out. Hence there is a constant stream of new-comers many of whom are potential or actual "bacillus-carriers." If these men are allowed to join the general files and to use the general latrines they will certainly infect them. We have not the means, it is needless to say, of conducting a bacteriological inquiry into the case of each new-comer, we must assume that all may be or are "bacillus-carriers," and make use of the seven to ten days of compulsory segregation to treat them with prophylactic doses of salts and perchloride of mercury, so as to get rid of as many as possible of the bacilli before the prisoners are allowed to mix in the general file.

I therefore advocate these measures of prevention as a convinced adherent of the view that sick and convalescing patients are the "bacillus-carriers," and are the danger especially to guard against, and I believe that once we grasp this essential fact it is not difficult to devise means of counteracting the evil influences. At first no doubt the action, necessitated by an acceptance of this view, is troublesome to enforce, but the more it is enforced the easier it becomes and perseverance will certainly be rewarded.

The Treatment of Dysentery.

I do not propose to say much on this subject. My advocacy of the value of the saline treatment has for years been known to the profession and it is mentioned in many of the text-books.

I believe that, in an otherwise healthy person, dysentery is usually an eminently curable disease, and long ago I laid it down as an axiom that in a jail dysentery, if promptly recognised and thoroughly treated, ceases to be a formidable disease.

In the first place we may ask what is the case-death-rate from dysentery?

The figures usually quoted * vary enormously. Ordinary hospital statistics give quite an erroneous view of the case-mortality of this disease. Mild cases do not usually come to public hospitals; too frequently cases are received only after repeated attacks and when the patients are worn out and emaciated, for no disease pulls one down quicker than a neglected dysentery. The figures quoted in text-books therefore of a case-death-rate of over 30 per cent. only refer to such neglected cases. If we take the cases of soldiers in a regiment or of prisoners in jail, where there is no hesitation in going to hospital, we find a very different state of affairs. The death-rate per hundred cases drops to a very small figure, something like 2 or 3 per cent. only. Some years ago I published details of over 1,000 *consecutive* cases of dysentery in jails treated by me with a death-rate of *less than one per cent.* (see Allbutt's *System*, Vol. II, Part II, p. 520). They were of all degrees of severity and they represent what can be done in a jail by the early recognition and the prompt and thorough treatment of dysentery. In all our Bengal jails the case-mortality is only 2 or 3 per cent., and I firmly believe this low rate could be still further reduced.

Only too often in investigating the deaths from dysentery in a jail I find the same story repeated, *viz.*, "complains of dysentery," "under observation," "admitted," "discharged," only to come back a few days or weeks later, for the same treatment to be repeated, and finally the patient comes to hospital and dies in 2 or 3 days, not of a very acute or fulminant attack, but of a neglected and badly treated dysentery.

To return to the treatment of the disease. There are many ways of treating dysentery successfully. Personally I know of none better than the judicious use of the salines (Sulphate of Soda). I have already referred to my publication of over 1,000 consecutive cases with only one death. Many other drugs have been found useful in other hands. Forster's vaccine has been very successful and seems destined to be of special use in the chronic cases, which always need infinite care and patience.

Rest in bed and low diet are essential, and in the milder cases almost sufficient. For native patients I know of no better food in the acute stage than what is

* See Manson's *Tropical Diseases*, Edition 1907, p. 426, and Allbutt's *System*, Edition 1907, Vol. II, Part 2, p. 488.

called *Mar dahi* (or strained rice-pulp, mixed with curdled milk). It is very important to see that the patient only very gradually is restored to full diet.

In conclusion, I again urge the importance of recognising the sick and convalescing "bacillus-carrier" as the great source of danger. With this clue borne in mind and logically followed out I believe it is possible to practically banish dysentery from any jail in a few months.

THE NATURE, PROPHYLAXIS, AND TREATMENT OF

DYSENTERY IN INDIAN PRISONS.

Being an Address to the Officers of the Jail Department.

By Capt. W. H. C. FORSTER, I.M.S., M.B , C.M. (Edin.), D.P.H. (Cantab.),

Lately on Special Duty to investigate the Subject.

The Nature, Prophylaxis, and Treatment of Dysentery is a large subject, and because the prevailing type of dysentery varies not only in different countries but also in different parts of the same country, I shall confine myself strictly to my experience of dysentery in Indian Prisons.

Definition of Dysentery.—When we attempt to define the term dysentery we at once become cognisant of the difficulties of the subject. Most writers define dysentery as an inflammatory disease of the large intestine characterised by certain clinical symptoms. A glance through the index of any of the modern text books however will show that conditions such as "Ulcerative Colitis," "Gangrenous Rectitis," etc., are described as separate diseases although there is nothing in the definition of dysentery to prevent these diseases from being included under that heading. If all inflammations of the large intestine accompanied by griping, tenesmus, and the passing of blood and slime in the stools are not dysentery, what then is the criterion by means of which we ought to be able to differentiate dysentery from other inflammatory diseases of the large intestine? I venture to suggest that there is no such criterion and that in truth the term dysentery is on a par with the term fever. Both are convenient and merely indicate the most prominent symptom of a great variety of diseases. As long as we use the term however we must be prepared to define it unless we adopt the historic attitude of J. S. Mill towards the definition of wealth, and content ourselves by saying that everyone has his own idea of the meaning of the term. During my work in Jails I made note of the conditions to which medical officers apply the term dysentery and as the result of my observations I have the following definition to offer. "Dysentery is a term applied to morbid conditions, irrespective of cause, characterised by the passing of stools containing or composed of mucus, blood, sloughs, or pus, either singly or in any possible combination."

The Causes of Dysentery.—My own classification of the causes of dysentery is as follows :—

1. Chronic venous congestion of the bowel as the result of obstruction to the portal system by tumours, etc.
2. Mechanical strangulation of portions of the gut as in Intussusception.
3. Inflammatory conditions in the neighbourhood of the gut as Prostatitis.
4. Inorganic poisons secreted from the circulatory system, *e.g.*, Mercury.
5. Inorganic and vegetable poisons acting locally during their passage through the intestine, *e.g.*, quick lime and crude soda.
6. Infection of the intestinal wall with specific bacteria, *e.g.*, Dysentery bacilli, Tubercle bacillus, etc.
7. Infection of the intestinal wall with certain Protozoa, *e.g.*, amœbæ ; the Leishman-Donnovan body, etc.
8. Irritation of the intestinal mucosa by parasites living in the gut, *e.g.*, Thread worms.

I shall confine myself to a very brief consideration of Nos. 6, 7 and 8 of this list.

Infection of the intestinal wall with specific bacteria.—Under this heading it will only be necessary to consider the following bacteria :—

1. Bacilli of the Dysentery Group.
2. The Tubercle Bacillus.
3. The Leprosy Bacillus.

Bacilli of the Dysentery group.—The majority of cases of dysentery occurring in jails are caused by these organisms. From 128 cases of dysentery I isolated dysentery bacilli from the stools of 81 cases. The most important of these organisms is Shiga's Bacillus because cases of dysentery due to this organism are the ones which tend to terminate fatally or to become chronic. I also found that the Y Bacillus of Hiss is capable of producing a very severe and even fatal form of dysentery. But as this organism is not nearly so common as Shiga's bacillus I cannot devote any time to its consideration.

As Shiga infections are very important from the point of view of the Jail Officer it will be necessary to consider them in detail :—

Clinically a Shiga case can be divided into three stages—

1. The incubation period.—This may last from two to ten days and there may be no bowel symptoms during the whole of this period. As the incubation stage is often characterised by pyrexia these cases are occasionally diagnosed as Malaria and called malarial dysentery when the typical bowel symptoms appear.

Failure to find the malaria parasites in the blood and the non-malarial type of the temperature ought to indicate the non-malarial nature of these cases.

2. The active stage of the disease.—This stage of the disease is usually but not invariably characterised by pyrexia which may last for a few days or persist with occasional intermissions for weeks. The motion consists entirely of blood and slime and are devoid of fæcal matter. Microscopically the slime shows a marked leucocytic (polynuclear) exudate. This leucocytic exudate is common to all bacillary dysenteries. Occasionally with a speculum one can see characteristic punched out ulcers in the rectum and from these ulcers the organisms can be recovered in almost pure culture. The duration of this stage varies considerably. In mild cases it may only last a few days and in severe cases it may last for weeks. This stage of the disease may terminate in several ways.

(1) It may gradually pass into the third stage of gradual recovery.

(2) It may persist without abatement to a fatal issue. In jails I have never seen that type of Shiga infection which terminates fatally in a few days. I have certainly seen cases which died within 48 hours of admission, but it was always found that these patients had been the subjects of dysentery for a long time and had concealed the fact until impending heart failure had driven them to hospital or led to the discovery of their condition. In jails death usually occurs from heart failure about the third week of the disease. Heart failure, due to the direct action of the dysentery toxin, is the great danger in all Shiga infections. It may occur at any time of the disease but rarely before the third week. It is often preceded by an apparent lull in the symptoms. Beware of heart failure in any severe case of dysentery which shows a sudden lull in the symptoms unaccompanied by any general improvement. This sudden lull is seen more frequently in children than in adults and is always of grave import. I have laid stress on the importance of guarding against heart failure because I do not think it is generally recognised. I remember well the case of a young officer of our own service who lost his life through not guarding sufficiently against this danger when suffering from the disease.

(3) The symptoms may persist with little or no abatement for six weeks or longer, the patient becoming more and more emaciated and finally dying from exhaustion.

(4) The disease may become chronic. There are two types of chronic dysentery resulting from a Shiga infection. In one the patient suffers from a chronic mucoid diarrhœa which may persist for years without any appreciable interval of health. In the other the patient has fairly long intervals of comparative health—usually during the cold period of the year—but frequently gets acute relapses followed by mucoid diarrhœa. When the disease becomes chronic the region of the sigmoid flexure and sometimes the ascending colon becomes thickened and indurated. A feeling of weight and dull pain in the region of the sigmoid is often complained of and palpation will generally reveal a tender spot.

3. The third stage or period of gradual recovery.—This stage is well known to you and the only point worth noting is that a little mucus may persist in the stools long after the patient has apparently recovered.

There are some further points about Bacillary Dysentery as a whole which are worth noting.

1. Cancrum Oris is an occasional, and in my experience, invariably fatal complication of Bacillary Dysentery. It usually occurs in the acute stage of the disease. Dysentery and Cancrum Oris frequently occur in Leishman-Donnovan infections and care is required in excluding these infections.

2. Repeated attacks of dysentery in the same individual are common in jails. In some cases these attacks are obviously relapses of the original infection but in other cases the connection with the original attack is not at all clear. For instance a man may have an acute attack of dysentery, get perfectly well, and do hard labour for months before he has another attack. At Midnapore I found that Shiga infections exhibit this peculiarity. I am of the opinion that these cases are also relapses but the reasons for this opinion must be reserved for another occasion.

3. Bacillary dysentery requires a longer convalescence than is usually accorded. The frequency of readmissions from the Convalescent and Post-Dysentery Gangs is sufficient proof of this statement.

4. Hepatitis is by no means uncommon in bacillary dysentery. Although the symptoms may be very severe abscess rarely, if ever, occurs.

5. Bacillary dysentery is most prevalent during the rains and the autumn months.

The Diagnosis of Bacillary Dysentery.—The best method is to isolate the bacilli from the stools but as this method will rarely be available reliance must be placed on the following points :—

(*a*) The character of the stools.—In the acute stage of bacillary dysentery the stools are devoid of fæcal matter. Microscopically the mucus shows the leucocytic exudate I have already spoken of. Except in cases of mixed infection there are no amœbæ in the stools. If, however, Magnesium Sulphate be given beforehand the stools will generally be found to contain amœbæ. I would therefore strongly advise you not to give Magnesium Sulphate before examining the stools.

(*b*) Pyrexia.—Pyrexia in the early stages is a common feature of Shiga infections. It also occurs with other types of dysentery bacilli.

(*c*) The agglutination test.—This test is not of much value. In the first place there are several kinds of dysentery bacilli and each case ought to be tested against each type. In my investigations I made observations on the value of this test for two organisms only, *viz.*, Shiga's Bacillus and Flexner's bacillus. I found that the agglutinins rarely show any marked increase before the fifth day and that in the case of Shiga infections the agglutinins

seldom show any very great increase. Briefly my views with regard to this test are as follows. The test should be performed twice, once on the fifth day and again on the twelfth day. The test is only of value when a positive indication is obtained.

Dysentery due to the tubercle bacillus and the leprosy bacillus.—I only mention these organisms because both Leprosy and Tubercle are very common in India and both these organisms can produce typical dysenteric symptoms. On the other hand people suffering from these diseases can be infected with true dysentery bacilli. The differential diagnosis is often very difficult but unless the stools are plated out reliance must be placed on general principles together with staining the exudate for the two organisms named.

Infection of the intestinal Wall with Protozoa.—Under this heading we need only consider malaria parasites and amœbæ. With regard to malaria parasites I may say at once that I have never seen a case of malarial dysentery and that I have never been able to trace any connection between malaria and dysentery. In fact I very much doubt if there is such a disease as malarial dysentery. I have seen several cases of so-called malaria dysentery but on plating out the stools these cases proved to be infections with Shiga's bacillus. The frequency of dysentery in the course of Leishman-Donnovan infections which were formerly regarded as malarial is also well known.

Amœbic Dysentery.—This disease is not nearly so common in jails as the bacillary form. In my experience amœbic cases constitute about 18 per cent. of the total cases in Bengal jails. There is an enormous literature on the subject so I shall content myself with a very brief resume of my own experiences in jails.

Magnesium sulphate should never be given before a stool is examined for amœbæ. If this drug is given amœbæ can be found in nearly all stools.

Amœbæ are seldom found in first attacks of dysentery. In fifty primary cases of dysentery I only found amœbæ three times. As these cases cleared up rapidly under ordinary treatment and never showed any tendency to recurrence it is doubtful if the amœbæ had any casual relationship to the symptoms.

I found amœbæ in the stools of two classes of cases. In one class the patients rapidly recovered and had no recurrences. In the other class the disease was very resistant to treatment and showed great tendency to recurrence.

In amœbic cases the stools practically always contain fæcal matter as well as slime.

In my experience uncomplicated cases of amœbic dysentery were never accompanied by Pyrexia.

In my experience the mucus from amœbic stools was usually, but not invariably, of a grumous nature and devoid of the leucocytic exudate I have referred to.

I was unable to satisfy myself that it is possible to distinguish different kinds of amœbæ by means of the microscope.

Amœbic dysentery in jails is a much more fatal disease than bacillary dysentery. Out of 24 cases two terminated fatally, one from hæmorrhage from the gut and the other from gangrene of the gut. The disease does not show any seasonal prevalence and takes the form of dropping cases occurring at irregular intervals. The bulk of the cases can be shown to have contracted the disease before admission to the jail but a small number of cases occur as the result of infection in the jail.

I have never seen any cases of liver abscess resulting from amœbic dysentery in jails, but, judging from the *post-mortem* records which I have examined, this disease is more frequent than would appear from the published statistics.

The diagnosis of amœbic dysentery must be made by means of the microscope. A diagnosis of amœbic dysentery should never be made until living, moving amœbæ have been seen. No warm stage is necessary as amœbæ move freely at room temperature in this country. For stained specimens I prefer Giemsa's stain to all others.

Irritation of the intestinal mucosa by parasites living in the guts.—This class of dysentery is aptly termed "Verminal Dysentery" by Manson. As we all know the vast majority of the inhabitants of this country harbour intestinal parasites of some kind or other and I am strongly of the opinion that once the physician is satisfied that the symptoms depend on the presence of intestinal parasites the disease should not be returned as dysentery. It is necessary however that you should be quite certain that the symptoms are due to intestinal parasites before returning the disease as such. This was the course followed at Midnapore when I worked there. At Midnapore we found that, of all intestinal parasites, thread worms most frequently give rise to dysenteric symptoms.

The Spread of Dysentery in a Jail.

For practical purposes this resolves itself into a consideration of the means by which Bacillary Dysentery is spread in a jail. The subject is a big one and I shall refer you to my report which will shortly be published for most of the evidence on which my statements are based.

Water-supply.—All available evidence shows that in jails the disease is not spread by the water-supply. Unless I am much mistaken this is also the view of most jail officers.

Dust.—The evidence is all against the disease being spread by this means.

The Milk Supply.—Milk is only supplied to certain prisoners and there is no evidence to show that the disease is spread in this way.

The General Food Supply.—I could not obtain any evidence to show that the disease is spread by infection of the general food supply.

Flies.—I could not get any direct evidence on this subject, but flies must always be regarded as possible agents in the spread of the disease. At Midnapore we noticed one particular kind of fly which had a great penchant for first visiting the latrines and then appearing in swarms at ration parade.

The lower Animals.—At Midnapore we found that calves were very liable to a fatal form of dysentery.

Owing to local prejudices we could never make a bacteriological examination of the stools during life, and after death we failed to isolate any dysentery bacilli from the intestine. Unfortunately the value of these examinations was marred by the presence of putrefaction. Nevertheless I think it is unwise to keep cows in a jail. Their dejecta is a certain source of flies and it is possible that infection may be conveyed in this way from the stools of dysenteric calves.

Soil Infection.—I could not get any evidence to show that the disease is spread in this way and an experiment which we performed at Midnapore showed that the disease is not spread in this way.

The Human Host.—The evidence is strongly in favour of the disease being spread by the human host. Briefly this statement is based on the following points.

1. The extra-corporeal existence of dysentery bacilli. I found that if pieces of cloth, soaked in living emulsions of dysentery bacilli be exposed to the sun's rays, the dysentery bacilli are all killed in two hours. If pieces of cloth treated in the same way be stored in almirahs the bacilli disappear in a few days. Practically they disappear almost as soon as the cloth gets dry.

I found that the growth of dysentery bacilli on solid media is influenced by temperature and humidity. I found, that other things being equal, the greater the humidity the longer the life of the bacilli. In this connection it may be noted that at Midnapore the dysentery curve corresponded closely with the rainfall curve. The maxima do not actually correspond as the dysentry curve attains its maximum a month later than the rainfall curve. The dysentery curve is at its lowest during the hot dry months of the year. During the rainy season when the humidity of the atmosphere closely approaches saturation any dysentery bacilli on the hands or on any instrument would live longer than in the hot dry season. The probability of these bacilli gaining access to the body of another person would therefore be greater in July than in April.

I made some experiments on the duration of dysentery bacilli in dysenteric discharges and found that they rapidly disappear. From these various experiments I came to the following conclusions :—

- (*a*) Under natural conditions the extra-corporeal existence of dysentery bacilli is very short.
- (*b*) A high air temperature combined with a low degree of humidity is unfavourable to the extra-corporeal existence of dysentery bacilli, but a moderate air temperature combined with a high degree of humidity is favourable to their extra-corporeal existence.
- (*c*) Dysentery bacilli do not carry on a saprophytic existence outside the human host.

2. *The class incidence of the disease.*—I found that the incidence of dysentery is unduly high amongst the following four classes of prisoners :—The under-trials, the new admissions undergoing segregation, the juveniles, and the convalescent gang. These classes of prisoners have one point in common, *viz.*, that they are more liable to come in contact with cases of dysentery or convalescents from dysentery than the other prisoners.

3. *Return cases.*—At Midnapore we had several return cases following the discharge of convalescents to a particular barrack. In Europeans one can often directly trace the infection. For example in three cases of dysentery in European children I found that in one case the mother suffered from chronic dysentery, and in the other two cases the native servants who attended to the children were the subjects of chronic dysentery.

For the reasons stated I came to the conclusion that the human host is the principal source of infection. If we grant this the question arises. How does the human host spread the disease ? Recent work on the spread of Enteric Fever suggests the answer that man spreads the disease by becoming "a carrier." I am however averse from the view that convalescents from dysentery become true "carriers" in the way that convalescents from Enteric Fever do. I am of the opinion that the subjects of bacillary dysentery are only capable of spreading the disease as long as they have unhealed lesions. Once the dysenteric lesions have been healed I very much doubt if these patients ever become "carriers" in the sense in which that word is at present used. I also take this opportunity of absolutely denying a statement attributed to me, *viz.*, that contacts with dysentery cases may become carriers in the same way as it has been shown that Enteric orderlies do. I may be wrong in my views as to dysentery carriers but as the subject is at present being investigated on the usual lines we may soon hope to know the real truth.

Returning to the main subject I should like to point out to you that patients who have suffered from bacillary dysentery may for months pass normal motions but all the time have unhealed lesions as indicated by tenderness on deep pressure and occasionally also by a feeling of weight and pain in the region affected. As long as they have these lesions they are theoretcially capable of infecting others and as the nature of the stools is the criterion used in discharging patients from hospital, the probability of infective persons being discharged to the General File amounts almost to a certainty. There are several ways in which the bacilli could be conveyed from one person to another but in my opinion the chain of events is generally as follows :—First the washing of the anus with water applied by the hand, then the clasping of hands as the gang is marched to work, and then the eating of the food with the fingers. It is of course possible that the general food supply may become infected through the medium of a cook who is acting as a host for dysentery bacilli but as I have already told you I have not yet been able to obtain any proof of this.

The Prophylaxis of Dysentery.

General Sanitation.—In this respect most Jail Officers have little to learn. On the contrary the sanitation of the big central jails which I have seen is something to be regarded with pride in this insanitary country.

The early admissions of suspected cases to hospital.—This is insisted upon by all Inspectors-General of Jails.

The detention of patients in hospital until they have been absolutely cured.—As a general rule when a patient has passed formed stools for a few days, eaten solid food without ill effects, and in other respects feels well he is discharged to the Convalescent Gang, or to the Post-Dysentery Gang, or to the General File. I found that this policy led to a number of re-admissions within a short time after discharge from hospital. At Midnapore Capt. Gillitt and I adopted the following routine :—Patients were only discharged from hospital after they had eaten ordinary food and passed normal motions for fifteen days. Further, no patient was discharged from hospital, however satisfactory his motions might be, if there was any evidence of unhealed lesions on palpation of the large intestine. This policy led to a great reduction in the number of re-admissions within the year and practically abolished re-admissions from the Post-Dysentery Gang. We only had one re-admission from this gang in a year. If properly carried out this policy ought to lessen the incidence rate of dysentery in a jail. I recently had an opportunity of seeing what happens when the opposite policy is carried out. The jail of which I speak had for years been a healthy jail. It is true that there had always been a considerable number of cases of dysentery per annum, averaging a little above 100, but deaths from this disease were few and far between. The ordinary routine had been carried out with regard to dysentery cases. Suddenly the routine was changed. Cases which appeared trivial were not admitted to hospital. Mild cases were only kept in hospital for a few days and then discharged to the Convalescent Gang. Practically only very severe cases were kept in hospital. The first result of this policy was of course a considerable reduction in the number of cases of dysentery in the hospital returns. But the advent of the rains soon altered the state of affairs. In the last six months of the year 300 cases of dysentery were admitted to hospital and the final figures for the year showed 344 cases of dysentery with 17 deaths. In six months this jail had been transformed into a "dysentery" jail and it will doubtless be a source of anxiety to the Inspector-General concerned for some time to come.

The segregation of convalescents from dysentery after discharge from hospital.—Theoretically this is done as a matter of routine in all jails. In practice however the segregation is often merely nominal. The Post-Dysentery gang ought to be strictly segregated and ought not to be allowed to come in contact with the other prisoners. Personally I think the real value of the Post-Dysentery gang lies in the fact that it increases your chances of detecting the incompletely recovered case—by virtue of a relapse—before he is passed into the General File.

Drug prophylaxis.—This is practised in many jails, the drug employed being generally either bael powder or some preparation of Mercury. I have not been able to judge the value of drug prophylaxis as a general measure, but I think it is certainly of value in the case of new admissions undergoing segregation. I found that quite a number of cases of dysentery occur within a very short time after admission to jail. At Midnapore we employed drug prophylaxis as a routine measure in the segregation yards and the results were very satisfactory

The Treatment of Dysentery.

The treatment of dysentery varies with the cause and the stage of the disease, but I shall confine myself to a few remarks on the application of Bacterio-therapeutics to the treatment of Bacillary and Amœbic Dysentery.

Acute Dysentery.—The serum treatment of acute bacillary dysentery has been in use for a good many years now and the published results show that in Europe the mortality can be greatly reduced by this form of treatment. In Indian prisons however the case-mortality from dysentery is very low. The Bengal jail returns for the years 1900-07 inclusive show a total of 28,144 cases of dysentery with a case-mortality of only 2·8 per cent. This low mortality is probably due to an acquired racial resistance to the disease. As serum treatment is always expensive I decided to try the value of systematic Vaccine-Therapy in acute dysentery. For details with regard to the preparation, etc., of the vaccine employed, together with the reasons which induced me to adopt this course, I must again refer you to my report and to articles which have already appeared in the medical press. For the present it will only be necessary to say that the vaccine employed was prepared from Shiga's bacillus. This method was tested for me at Midnapore by Capt. Gillitt with the following result :—

Before the introduction of systematic Vaccine-Therapy—

36 cases with 2 deaths = a case-mortality of 5·5 per cent.

After the introduction of Vaccine Therapy—

114 cases with 1 death = a case-mortality of 0·8 per cent.

The average case-mortality from dysentery in this jail for the previous eight years was 6·3 per cent. The Midnapore figures are satisfactory, but they are not large enough to admit of any safe deductions. I had hoped that by now the figures would have been much larger but unfortunately Capt. Gillitt was incapacitated for the greater part of last year by an attack of enteric fever. Since his return to duty he has resumed this treatment and at present his books show 70 treated cases with no deaths. This form of treatment is also being tried in other jails and so far the reports received are very satisfactory, with one exception. In this case, although I am not yet in possession of the details, it appears that a very fatal form of dysentery suddenly made its appearance in the jail and vaccine treatment had no effect on these cases. Apart from saving life I expressed the opinion that Vaccine-Therapy would diminish the number of cases of chronic dysentery resulting from an acute bacillary infection. This was undoubtedly the case at Midnapore and in this fact lies the greatest value of vaccine treatment. The cases which recover show no tendency to recurrence and in consequence the chances of returning infective persons to the General

File are greatly reduced. Chronic dysentery of bacillary origin is very common in India and particularly so in Europeans. I have no hesitation in saying that the systematic use of Vaccine-Therapy in the treatment of dysentery would result in a material diminution of the number of these cases.

Chronic Dysentery.—Here again I would recommend you to try Vaccine-Therapy before exhausting the resources of the pharmacopœia. In doing so however I wish to caution you against expecting recovery in every case. The pathology of chronic dysentery is complex and you should be prepared to meet with failures. With regard to chronic dysentery of an amœbic nature I have for some time now been testing the value of a Shiga Vaccine combined with mercury. The work has temporarily been interrupted by other duties but the results so far are very encouraging. In my report I have discussed the principles involved and given some of the results so I shall confine myself to a few remarks on the subject. The mercury is best given in the form of a pure solution of the Perchloride in the strength of 1 in a 1,000. The drug should not be pushed, three drachms per diem for six days with an interval of four days before resuming being sufficient. Tabloid preparations are now on the market from which a 1 in a 1,000 solution can easily be made up. The vaccine is given at comparatively long intervals (14 days) and the treatment must be kept up for several months. In judging the results no patient should be regarded as cured until he has remained perfectly well for a year after the treatment has been discontinued.

DISCUSSION.

Dr. L. Rogers, I.M.S., said :—I regret I could not be present to hear all the papers which have been read on dysentery, but as the subject has long interested me, I may perhaps be permitted to make a few remarks In the first place there are undoubtedly very marked differences, both macroscopically and microscopically, between the bacillary and the amœbic types of dysentery. The bacillary form is at first essentially a disease of the mucous coat of the large bowel, being accompanied by a general inflammatory thickening and small celled infiltration, with extensive necrosis of the glandular epithelium. Later ulceration takes place, resulting in irregular serpiginous depressions in a generally thickened surface. In the amœbic form, on the other hand, the primary lesion is in the submucous coat, which becomes greatly thickened by a gelatinous effusion, with comparatively few inflammatory cells, but containing living amœbæ. These form raised patches, from over the surface of which the mucous glands separate, exposing the yellow material. On cutting sections through the edge of such an early ulcer the mucous glands will be found practically normal close up to the edge of the ulcer, instead of the widespread necrosis of the bacillary form. Beyond the raised thickened edge the mucous membrane is quite healthy, so that here we have raised yellow rounded or oval separate patches standing up from a surrounding normal mucous membrane. that is just the opposite condition to the bacillary form. In the slighter, and often latent forms of amœbic dysentery found frequently after death from liver abscess the disease is commonly limited to the cæcum and ascending colon, when typical dysenteric symptoms are usually absent, thus giving rise to the false impression that the liver abscess is independent of earlier bowel disease. The lower part of the ileum almost always escapes in amœbic dysentery in spite of the common involvement of the cæcum, a fact which may possibly be explained by some unpublished observations I have made on the action of acids and alkalies on the amœbæ of liver abscess. They showed that these had a much greater power of resisting acids than alkalies, so that the cæcum would furnish a suitable site for their development from the encysted spore forms which are the probably infective agent of the disease. In very extensive fatal amœbic dysentery it is strange how often the disease is diagnosed as anything but dysentery, sloughing of the rectum, and even constipation having been noted before death, the latter having been due to peritonitis from perforation of the very soft blotting paper like wall of the large bowel. Much more combined clinical and microscopical work is required before it will be possible to recognise in the wards all the types of dysentery, and to know the best treatment for each variety. There appears to me to be no more important subject for prolonged study than the clinical and pathological differentiation of the dysenteries of tropical climates.

Major R. Heard, I.M.S., said :—Captain Forster has stated that he had avoided any reference to predisposing causes of dysentery in jails. He has, however, excluded malaria as a cause of dysentery, by his researches. This agrees with my clinical experience, but it was generally assumed that the incidence of dysentery in jails was influenced by this disease. It appeared to be a question of opportunity for injection and dosage. A very important practical matter for the consideration of jail officers is the oral hygiene of the prisoners, and I attributed the extermination of dysentery in a jail, some ten years ago, to this point.

The prisoners deprived of the opportunities of thoroughly cleaning the teeth for months, or possibly years, the gums and mouth assume unhealthy conditions ; and apart from ill-health from indigestion, due to imperfect mastication of food, the conditions are favourable for the multiplication of the injection in the mouth and a consequent increase in dose.

Every prisoner should be provided with a "tooth stick," after the custom of the country, and the teeth and gums carefully inspected on parades.

Dr. Dhanjibhai H. Mehta (Baroda), said :—I quite agree with Dr. Buchanan that the predisposing causes are of great importance as regards attacks in jails. There is danger in badly cooked vegetables and one of my predecessors in office has reported that a certain vegetable of the Cucurbitacæ order called "Toorian" (તુરીઆં) in Gujrati is noticed to bring on dysentery in cases predisposed to it.

Dysentery is more or less prevalent in the Baroda Central Jail during the early part of the monsoon, and though a few serious cases occur the incidence of mortality is very low, thus proving Dr. Buchanan's assertion that if cases are brought under treatment early as in institutions like jails, the disease is easily curable. The following table shows the number of cases and deaths from the disease in the Baroda Jail :—

Years.		Cases.	Deaths.	Percentage of mortality.
1902·03	...	50	0	0
1903·04	...	65	2	3
1904·05	...	22	0	0
1905·06	...	20	0	0
1906·07	...	29	2	6·8
1907·08	...	42	0	0

Percentage on all cases 1·7.

The two deaths in 1906-07 were really in neglected cases—cases that had been admitted more than twice before and had apparently not been thoroughly cured when discharged.

As to treatment I may only add one word and that is that I have found the following efficacious :—

7 clean leaves of Jasminum sambai N. O. Jasminaceæ, called "Moghra" મોઘરા in Gujrati, should be pounded in a glass mortar with an ounce of water and a drachm of sugar, strained through muslin and given twice a day, the mixture to be prepared fresh each time. The effect generally is to lessen the frequency of motions by half, to relieve tenesmus and tormina and lessen the discharge of blood and slime to a great extent

within 24 to 48 hours and to cause the evacuation of a formed motion within 72 hours. Complete cure often occurs in from 2 to 4 days. Care should be taken to select well-grown green leaves and to wash them clean before use.

Dr. J. J. van Loghem, Medan, Sumatra, Dutch Indies, said :— The important paper of Capt. Forster, having not been printed before, I am not able to discuss all the details he gave about bacillary dysentery and the different types of dysenteric bacilli. So I will only give some personal remarks about dysentery in Sumatra.

On 268 post-mortems we made last year in the pathological Laboratory in Medan, 30 deaths were due to amœbic dysentery. In about 25 cases there was a severe non-amœbic colitis, which caused death. All these post-mortems concerned Chinese and Japanese coolies of tobacco estates.

Among the fatally ended non-amœbic dysentery I found several times the bacillus Shiga as the cause of death. In mild cases of dysentery of Europeans and natives I found besides the Shiga bacillus many pseudo-dysentery bacilli of different types.

I do not agree with Captain Forster that it is so very difficult to obtain serums of animals against pseudo-dysentery bacilli. He did not mention the species of animal he used, I can state that goats give in a few weeks serums against pseudo-dysentery bacilli with titre of 2,000 and more. Rabbits are still more useful for differentiation of the different types of pseudo-dysentery bacilli.

For the diagnosis of bacillary dysentery in the beginning of the disease, the cultivation from the stool is the best method. The agglutination test has also value, especially the progression of the titre in the course of the disease. The agglutination test in dysentery is not so easily judged as it is in typhoid fever.

Then, I will draw your attention to some anatomical specimens of amœbic and bacillary dysentery: especially to some atypical cases, which seem to be interesting.

Demonstration of—

(1) Shiga dysentery of the colon and *the ileum.*
(2) Colitis by bac. pseudo-dysenteriæ, with secondary typhoid.
(3) Amœbic dysentery of the colon and *the ileum*: secondary bacillary dysentery of the upper part of *the ileum.*

NOTE ON A
MIXED TYPHOID AND DYSENTERY VACCINE

And on Vaccination with Live Cultures.

By ALDO CASTELLANI, M.D.,

Director of the Clinique of Tropical Medicine, Colombo (Ceylon).

Typhoid and bacillary dysentery are probably the commonest diseases, except malaria, attacking Europeans in the tropics. Wright's vaccine is now generally admitted to be of great advantage for the prevention of typhoid; and, as regards the prevention of dysentery, vaccines have been prepared by Shiga in Japan, Kruse in Germany, and myself in Ceylon, with various methods. It would be of advantage to have a vaccine which should at the same time give protection against typhoid and dysentery, instead of, as at present, being obliged to inoculate different vaccines at different times.

In 1901, while working at Bonn under the direction of Prof. Kruse, I proved that by inoculating an animal with two different bacteria at the same time, the blood produced agglutinins and immune bodies for both germs; and that the amount of agglutinins and immune bodies for each germ was about the same as in those animals inoculated with one germ only. For example,—inoculating a rabbit with typhoid bacillus and the pseudo-dysentery bacillus at the same time, the blood of the rabbit developed the same amount of agglutinins and immune bodies for the typhoid bacillus as control animals inoculated with typhoid only, and the same amount of pseudo-dysentery agglutinins and immune bodies as rabbits inoculated with pseudo-dysentery only.

I demonstrated that even inoculating rabbits with three different germs the amount of agglutinins and protective bodies elaborated, for each germ, was almost the same as in animals inoculated with one germ only, respectively.

Moreover, I could confirm that when the immunisation is obtained by a single inoculation—within a certain limit—the amounts of agglutinins and immune bodies elaborated is not in proportion to the amount of culture injected; so if a series of rabbits are inoculated with 2 c.c. each of a typhoid culture, and another series with 4 c.c. each, the agglutinins formed are about the same in both series of animals.

I have continued these experiments in Ceylon and I have had the same results, as will be seen by comparing Tables I, II and III with IV, V and VI.

TABLE I.

Rabbits Inoculated with 4 c.c. of live mixed Broth Cultures of Bac. Typhosus and Bac. Pseudo-Dysentericus (Kruse).

No. of Rabbit.	Agglutination limit before Inoculation.		Agglutination Limits after Inoculation													
			3rd Day.		10th Day.		15th Day.		30th Day.		60th Day.		120th Day.		150th Day.	
	B. Typ.	B. Ps.-Dy.	B. Typ.	B. Ps.-Dy.	B. Typ.	B. Ps.-Dy.	B. Typ.	B. Ps.-Dy.	B. Typ.	B. Ps.-Dy.	B. Typ.	B. Ps.-Dy.	B. Typ.	B. Ps.-Dy.	B. Typ.	B. Ps.-Dy.
1	10	20	50	100	4,000	3,000	4,000	2,000	3,200	500	1,000	200	500	200	250	100
2	...	10	20	80	10,000	2,500	6,000	2,000	4,000	1,000	2,000	400	200	100	...	...
3	...	...	150	60	10,000	3,000	10.000	2,500	6,000	1,200	1,000	100	100	60	40	60
4	...	10	100	120	6,000	2,000	5,000	2,000	2,000	400	500	150	100	50	...	...

TABLE II.

Rabbits Inoculated with 4 c.c. of live mixed Broth Cultures of Bac. Typhosus and a strain of Bac. Coli.

No. of Rabbit.	Agglutination limit before Inoculation.		Agglutination Limits after Inoculation.													
			3rd Day		10th Day.		15th Day.		30th Day.		60th Day.		120th Day.		150th Day.	
	B. Typ.	B. Coli.	B. Typ.	B. Coli.	B. Typ.	B. Coli.	B. Typ.	B. Coli.	B. Typ.	B. Coli.	B. Typ.	B. Coli.	B. Typ.	B. Coli.	B. Typ.	B. Coli.
5	...	10	60	40	6,000	2,000	8,000	2,000	3,000	600	500	60	200	40	40	20
6	...	...	120	60	10,000	1,200	6,000	1,000	4,000	300	...	...	...	...	...	...
7	...	20	20	40	10,000	3,000	10,000	1,500	2.500	200	500	50	100	30	...	...

TABLE III.

Rabbits Inoculated with 4 c.c. of live mixed Broth Cultures of Bac. Typhosus, Bac. Pseudo-Dysentericus (Kruse) and a Strain of Bac. Coli.

No. of Rabbit.	Agglutination limit before inoculation.			Agglutination Limits after Inoculation.																				
				3rd Day.			10th Day.			15th Day.			30th Day.			60th Day.			120th Day.			150th Day.		
	B. Ty.	B. Ps.	B. Col.	B. Ty.	B. Ps.	B. Col.	B. Ty.	B. Ps.	B. Col.	B. Ty.	B. Ps.	B. Col.	B. Ty.	B. Ps.	B. Col.	B. Ty.	B.Ps.	B. Col.	B. Ty.	B. Ps.	B. Col.	B. Ty.	B. Ps.	B.Col.
8	..	..	10	100	60	120	10,000	4,000	2,000	6,000	2,000	1,200	4,000	500	600	1,000	100	100	100	40	20	20	10	10
9	..	10	10	150	120	60	3,000	2,000	1,200	3,000	1,000	500	1,000	200	100	500	60	60	..	..	..	..	..	..
10	..	..	20	20	40	40	5,000	2,000	1,000	4,000	2,000	1,500	2,000	400	300	800	300	500	..	..	..	..	..	..

TABLE IV.

Rabbits Inoculated with 2 c. c. of a live Bac. Typhosus Broth Culture.

No. of Rabbit.	Agglutination limit before Inoculation.	Agglutination Limits after Inoculation.						
		3rd Day.	10th Day.	15th Day.	30th Day.	60th Day.	120th Day.	150th Day.
11	......	50	8,000	8,000	2,500	1,000	50	......
12	......	250	10,000	10,000	6,000	3,000	500	200
13	10	100	4,000	4,000	1,500	200	50	20
14	......	40	10,000	10,000	4,000	100	......	......
15	......	40	3,000	3,000	1,500	......	......	......

TABLE V.

Rabbits Inoculated with 2 c. c. of a live Bac. Pseudo-Dysentericus (Kruse) Broth Culture.

No. of Rabbit.	Agglutination limit before inoculation.	Agglutination Limits after Inoculation.						
		3rd Day.	10th Day.	15th Day.	30th Day.	60th Day.	120th Day.	150th Day.
16	20	80	3,000	3,000	400	40	40	40
17	40	200	2,000	3,000	1,500	500	100	60
18	......	50	1,500	2,000	250	......	......	......
19	20	200	3,000	1,500	200	.....	......	......

TABLE VI.

Rabbits Inoculated with 2 c.c. of a live Bac. Coli Broth-Culture (same strain as used in Tables II and III).

No. of Rabbit.	Agglutination limit before Inoculation.	Agglutination Limits after Inoculation.						
		3rd Day.	10th Day.	15th Day.	30th Day	60th Day.	120th Day.	150th Day.
20	20	50	2,500	2,000	500	100	20	20
21	20	40	1,000	1,500	200	......	......	......
22	10	80	2,500	3,000	500	100	20	20

As regards experiments with mixed typhoid and dysentery cultures,—these cannot be performed in rabbits, as these animals stand very badly inoculations of the dysentery bacillus (Kruse-Shiga type). I have therefore used goats; the results are similar to those I have obtained in rabbits using typhoid and pseudo-dysentery cultures.

Experiments in Man with the Mixed Typhoid and Dysentery Vaccine.

Broth cultures and pepton-water cultures are used. I generally prefer pepton-water cultures, as broth cultures of dysentery often give rise to serious symptoms when inoculated. The cultures are prepared by inoculating some tubes with two milligrams each of a virulent dysentery culture (Kruse-Shiga type). The tubes are incubated at 35° for 48 hours. They are then kept for an hour at a temperature of 60°. The typhoid cultures are then mixed with the dysentery cultures and a trace of carbolic may be added. This mixture, which must of course be kept in sterile tubes, is the mixed vaccine; the vaccines can be standardized using Wright's method, before mixing them. Of this mixed vaccine I inoculate one c.c. if the medium used was pepton-water; ½ c.c. or ⅝ if the medium used was broth; after a week I repeat the inoculation generally using the double dose. The inoculation is harmless; the symptoms of reaction, local and general, are not sensibly more marked than by inoculating typhoid vaccine alone or dysentery vaccine only. After two to six days the inoculated individuals may present some agglutinins for the typhoid and dysentery bacilli. The amount of agglutinins developed is always extremely small, but in my experience this is the case also in individuals inoculated with typhoid vaccine only. As regards the degree of immunization induced, it appears to be the same as that induced by using the vaccines separately. Using the same method I have prepared a polyvalent vaccine of typhoid, paratyphoid B, dysentery of Kruse-Shiga type, and dysentery of the Flexner type. I now frequently use the following method and have found the results satisfactory:—

1st inoculation.—Ordinary typhoid vaccine cultures, heated at between 55 and 60.

2nd inoculation.—Two weeks later—attenuated live cultures.

Typhoid and Dysentery Vaccination with Live Cultures.

It is well known, after the experiments of Strong and others that the inoculation of cultures killed by heat or by chemicals does not induce in man, in many cases, a high degree of immunization. Hence Strong has advocated in plague the inoculation of live cultures, which by reason of being grown in the laboratory for several years had lost their virulence. I have recommended and used the inoculation of a typhoid vaccine, using live cultures and prepared as follows:—

1. Tubes of broth or pepton-water are inoculated with two milligrams each of a virulent agar culture. I generally prefer pepton-water cultures.

2. After 48 hours incubation at 35°, the tubes are kept in a water bath at a temperature of 50° for one hour. The bacteriological examination of the cultures, after this, will show that they are still alive as they can be transplanted in agar and all the other media; the germs, however, are sufficiently attenuated not to produce dangerous symptoms. Of these attenuated cultures I inoculate ½ c.c. and after a week, 1 c.c. In the same way I have produced an anti-dysentery vaccine; and also a mixed anti-typhoid and anti-dysentery vaccine. The details of this investigation will be published elsewhere but I may state here that the conclusion to which I have come is that the use of typhoid live cultures, attenuated by heat as a vaccine, is harmless,—though in some cases the local reaction may be more severe than in using dead cultures. In man the amount of immune bodies and agglutinins produced is distinctly in excess of that produced by using dead cultures, when in several cases the amount of immune bodies and agglutinins elaborated is insignificant.

THE ETIOLOGY, DIAGNOSIS, AND PROPHYLAXIS OF ENTERIC FEVER IN INDIA.

By Lieut.-Colonel D. SEMPLE, M.D., R.A.M.C. (Retired).

Director, Central Research Institute, Kasauli, Punjab.

In this paper I purpose dealing with enteric fever from a bacteriological point of view, and, in doing so, I shall be guided by practical experience gained during a recent investigation of the subject at the Central Research Institute, Kasauli.[1]

I shall confine my remarks principally to the disease as it is met with amongst Europeans in India.

Enteric fever is one of the most formidable diseases, which Europeans in India have to contend with. This is due not only to the amount of sickness and to the number of deaths which it is responsible for, but also to the expensive sanitary measures which are considered necessary to prevent its spread.

One has only to observe the efforts put forth to stamp out this disease in the cantonments of European troops by those responsible for the health of our army in India, to appreciate the importance which the Military authorities attach to the subject. It is most important that any facts which tend

[1] An enquiry on enteric fever in India. Scientific Memoirs of the officers of the Medical and Sanitary Departments of Government of India, No. 32.

either directly, or indirectly, to throw light on the sources and channels of infection, or to diminish the incidence of enteric amongst Europeans in India should be strenuously sought after. No efforts should be spared in our endeavours to trace the source of infection in every case. A single case in which the source of infection has been traced by evidence based on scientific facts is of more value in suggesting methods of prevention than many cases in which the evidence is based on probabilities or guess work.

Before intelligent and successful preventive measures can be adopted in connection with any infectious disease, it is necessary to know what is the agent which gives rise to the disease, where the storehouse of this causal agent is to be found, and the means by which susceptible persons get infected, or, in other words, what is the infection? where does it exist? how is it kept up? how is it conveyed?

A few leading facts of this nature lie at the root of all scientific preventive measures.

In regard to enteric fever, before the solution of these problems we were more or less in the dark, and obliged to fall back upon general sanitary measures, not knowing whether we were doing too little or too much.

In 1880 Eberth first recognised the bacillus typhosus as the causal agent of typhoid fever; and a few years later Gaffky was able to obtain the germ in pure culture from the spleen, liver, and mesenteric glands of patients who had died from the disease. On this account it is often referred to as the Eberth-Gaffky bacillus, and sometimes as Eberth's bacillus. For over 20 years matters remained practically at this stage, with the exception that a few more facts were added to our knowledge of the distribution of the bacillus in the tissues, secretions, and excretions of patients, but, as formerly, general sanitary measures were all that we had to fall back upon for the prevention and spread of the disease.

Koch in 1902-03 solved the problem of the storehouse of the virus in Nature. In conjunction with Frosch and other workers he proved that a percentage of those who had passed through an attack of enteric fever continued to harbour the parasite for prolonged periods, excreting it either in their fæces, or urine, or in both. He found not only was this the case in those who had passed through a typical attack of the disease, but that it might also occur after the slightest forms of infection, or where the disease had passed unrecognised. He also proved that the saprophytic existence of the bacillus outside the body of man is comparatively short.

From these two important facts the conclusions he arrived at were that man was the storehouse of the bacillus in Nature, and that susceptible persons were infected either directly or indirectly from this source alone. The work initiated by Koch was subsequently confirmed by Lentz, Conradi, Kayser and others. To these workers we are indebted for our knowledge of the early facts about chronic bacilli carriers. They proved that the "chronic carrier" is a source of danger to the community by acting as a reservoir and disseminator of infection for weeks, months, or years. Some of these carrier cases were kept under daily bacteriological examination for prolonged periods of time, with the result that the excretion of infection in the urine and fæces was found to be intermittent in character, and that the intervals varied greatly in different cases; some being almost continuously infective, and others free for weeks at a time.

About the same time several other important facts emanated from the German School of workers, such as the demonstration of bacilli in the blood of enteric fever cases very early in the disease; improved methods of cultivating B. typhosus from the blood, urine and fæces (Drigalski, Conradi, and Kayser); the isolation of the bacillus from the excretions of healthy persons with no history of enteric, but who had been in contact with enteric cases, or had lived in their vicinity and under conditions where infection was possible.

The knowledge of these new facts served as a sound basis upon which to build up scientific preventive measures, and so prevented the waste of useless energy in other directions. It follows from all these facts that every fresh case of enteric fever means either direct or indirect infection from a previous case, and that each new case is in turn a focus from which susceptible persons may get infected.

Man alone being susceptible to a virus which is short-lived outside the human body, the disease can be kept up only by being passed on from man to man. The channels by which this transference is accomplished are numerous, but, broadly speaking, they all resolve themselves into the fact that a susceptible person swallows the causal micro-organism, in contaminated milk, food, or water, or it may be introduced by contaminated hands, flies, and articles coming in contact with his mouth, food or drink.

We have no proof that biting-insects take any part in spreading enteric, nor is it likely that this method of infection could possibly occur, owing to the fact that living typhoid germs can be injected hypodermically in a healthy person without causing infection.

The cause of enteric and the channels by which the infection gains an entrance to the human body have been known for many years; but the storehouse of the virus in Nature, and the life of the virus outside the body of man are facts of recent date. Before the discovery of these facts the origin of most epidemic and endemic cases was mere guess work, and often wrapped in obscurity.

We cannot go beyond man in our search for the cause of typhoid fever; and, so far as we know, it would be a fruitless task, and a waste of time, to search for a store-house of the infection elsewhere.

Preventive measures based on a knowledge of the store-house of the causal agent would be more likely to prove successful than general sanitary measure which ignored this one item. Malta fever is a case in point. The causal agent had been known for years, but the most elaborate sanitary measures made little or no impression in diminishing the ravages of the disease in Malta, until at last a store-house of the virus was found to be the goat. As soon as goat's milk was proved to be a fruitful source of infection, and measures were taken to eliminate this source, the incidence of the disease at once subsided, and it has now practically disappeared from our soldiers and sailors at Malta.

A campaign against enteric fever can prove successful only when measures are directed against the sources of infection, *viz.*, the *enteric fever patient* and the *bacillus carrier.*

II. *The causal Micro-organisms.*

By enteric fever is generally meant an infection caused by the Bacillus typhosus of Eberth, but within the last few years the term has come to have a wider meaning, and it is now used to comprehend an infection which may be caused by any one of a group of bacilli more or less allied to each other. If we accept the term enteric fever to include the typhoid and paratyphoid infections, it has been conclusively demonstrated that there are at least three different micro-organisms, any one of which may give rise to this condition.

1. B. typhosus of Eberth, the causal agent of typhoid fever.
2. B. paratyphosus A. (Brion and Kayser), and
3. B. paratyphosus B. (Schottmuller), the causal agents of paratyphoid A. and paratyphoid B. respectively.

In addition, a fever, clinically indistinguishable in its later stages from enteric fever, may be caused by any one of a group of other bacilli connected with meat poisoning, and more or less allied to the paratyphoid group. The known bacilli of this group are Gaertner's bacillus, and the Enteritidis bacillus (Flugge-Kaensche); the former of these is identical with the rat pathogenic micro-organisms of Dunbar, Danysz, and Issatzehenke; and the latter with the Hog cholera group. From a clinical and epidemiological point of view we must classify the fever produced by any of these micro-organisms as enteric. A differentiation of the infecting agent can only be arrived at by bacteriological methods such as blood cultures, serum tests, etc.

In all these infections the infecting agent is found in the blood at some period of the illness; possibly during the whole of the fever periods, and on this account an exact diagnosis is often comparatively easy.

Modern methods of investigation have changed our ideas in regard to what constitutes an enteric infection. Widal's reaction, the isolation of the causal micro-organisms either from the blood, fæces, or urine during life, or from the internal organs after death, has enabled us to arrive at a correct diagnosis when clinical methods fail, and to distinguish between typhoid and paratyphoid infections. It would serve no useful purpose to describe these different micro-organisms in detail, as their description is fully given in most text books in bacteriology.

By far the greater majority of cases of enteric fever are caused by the B. typhosus of Eberth, and would, therefore, come under the heading typhoid fever.

The proportion of cases of paratyphoid varies according to different observers from less than 3 per cent. to 10 per cent.

Boycott[1] states that he met with 3 cases of paratyphoid in the investigation of 176 cases of enteric.

Kolle[2] estimates than 10 per cent. of enteric fever cases are paratyphoid.

During a recent investigation of enteric fever in India at the Central Research Institute, Kasauli, we met with 6 cases of paratyphoid infections in 91 cases in which the causal micro-organism was isolated. Of these six cases 4 were caused by B. paratyphosus A. and 2 by B. paratyphosus B. One of the paratyphoid A. cases was a mixed infection, as the B. typhosus of Eberth was also isolated from this case.

No doubt the percentage varies in different countries. Owing to the fact that it is only within the past few years that paratyphoid infections have been recognised and proved by bacteriological methods, it is too soon to lay down a percentage of cases with any degree of accuracy. Clinically it is not possible to distinguish typhoid from paratyphoid infections. A serum reaction properly interpreted would assist a good deal, but for accuracy it cannot be compared to a cultivation of the infecting micro-organisms from the blood or dejecta during life, or from the tissues after death.

With the exception of the wider distribution in nature of the paratyphoid micro-organisms, facts applicable to typhoid apply equally to paratyphoid infections.

When we follow up the life-history of these micro-organisms we find that the most important facts connected with them are:

1. B. typhosus is dependent on man for its existence. Its life outside the human body even under the most favourable conditions is comparatively short.
2. The paratyphoid groups have a wider distribution in Nature than the B. typhosus. In

[1] Boycott. Journal of Hygiene, January, 1906.
Kolle, Zeit. fur Hygiene u Inf. 52, page 28, 1906.

addition to being found in man they may be found in the intestinal tract and tissues of some of the lower animals.

III. *The Relation of the Causal Micro-organisms to Infected Persons.*

(*A*) *During an Attack of the Disease.*

Enteric fever is a septicæmia. At some period of the fever, probably during the whole of the fever period, the infective agent is found in the blood, and can be cultivated from it in suitable media.

The specific virus, when swallowed, is taken up by the lymphatic tissue of the digestive tract, where multiplication takes place; soon it finds its way to the mesenteric lymphatic glands, where further increase occurs, and from these situations it is passed on to the blood stream when the disease becomes a bacteraemia.

Owing to the fact that inflammation of the tonsils and fauces is a common symptom shortly before or during the very early stages of enteric fever, it is very possible that the virus in some cases gains an entrance *via* the lymphatic tissue of the tonsils. The multiplication of the bacilli mostly takes place in the lymphatic tissues of the body, and from these foci they are fed into the blood stream during the course of the disease, and gradually killed off. It is questionable whether any multiplication takes place in the blood stream; on the contrary the bactericidal effects of human blood on typhoid bacilli would lead us to expect that they are constantly being killed off. That they are capable of surviving for some time in the blood is proved by the positive results of cultivations made from this fluid.

Through the medium of the blood the bacilli are lodged in the liver, spleen, kidneys, and bone marrow, and form foci of multiplication in these situations. The excretory passages of the bile and urine get their infections from the liver and kidneys respectively. Typhoid and paratyphoid bacilli grow well in bile and urine; both are excellent media. During an attack of the disease the B. typhosus is rarely (probably never) absent from the gall-bladder. From this situation they are excreted into the intestinal tract with the bile, and mix with the intestinal contents where, according to Lentz[3], they do not multiply but are liable to perish.

In 42 samples of bile received at the Central Research Institute, Kasauli, from various parts of India, and taken from post mortem cases of fever diagnosed as enteric before death, the B. typhosus was isolated from 27, which gives a percentage of 64·3. Many of the samples when received were found to be grossly contaminated, and several contained B. Coli. It is possible that the contaminating micro-organisms may have killed off the B. typhosus in some of the samples during transit.

We rarely find Eberth's bacillus in the faeces during the early stages of the disease. This may be due to the fact that bacilli are not excreted in the bile in large numbers until the disease has made some progress. A few bacilli passing into the intestinal tract would be liable to perish there, or to escape detection in an examination of the faeces. When several examinations of the faeces are made after the tenth day of the disease, the bacillus may be found in about 80 per cent. of cases, but with only one examination the percentage of positive results would not be over 30 per cent., possibly a great deal less.

Cultivations made from the urine early in the disease seldom give positive results. Towards the 3rd week the percentage of positive results would vary from 25 per cent. to 30 per cent. Wright and Semple[1] in 1895 drew attention to the urine as a potential source of infection in patients suffering from enteric fever. They isolated the bacillus from the urine and rose spots of a series of cases at Netley and Southampton, and utilized the fact of the presence of infection in the kidneys, urine, and rose spots, as an argument in favour of the disease being a septicæmia.

The frequency with which the bacilli are found in the blood depends on the stage of the disease when cultivations are made, and on the medium employed. Examinations made during the 1st and 2nd weeks give a higher percentage of positive results than those later on.

Birt[2] collected the results of 37 investigations on cultivations made from the blood in cases of enteric fever. Out of 1303 cases examined Eberth's bacillus was isolated in 1150, which gives 88·4 per cent. but it is not mentioned at what period of the disease the examinations were made. No doubt the examinations were made at different periods, and probably more than one examination in some of the cases. Stühlern[3] examined 30 cases of enteric, and made cultivations from the blood every 3—4 days during the fever period. He found the bacillus in every case, and in greatest numbers during the early stages of the fever. As the disease progressed the bacilli became fewer and fewer, and finally disappeared when the temperature reached normal.

At the Central Research Institute, Kasauli, cultivations were made from the blood of 49 cases of enteric fever among Europeans, one cultivation from each case. The stages of the disease at which blood was taken varied from the 1st to the end of the 3rd week, but most of the examinations were made during the 2nd week. Typhoid bacilli were found in 32 cases, which gives 65·3 per cent. Of the 17 negative cases, typhoid bacilli were subsequently isolated from the urine or fæces of 10, and the remaining 7 gave a well marked Widal reaction on B. typhosus.

[3] Lentz XIV. International Congress for Hygiene and Demography. Berlin, September 1907.

[1] Wright and Semple. On the presence of typhoid bacilli in the urine of patients suffering from typhoid fever. *Lancet*, July 27th 1895.

[2] Brit. Journal of the R. A. M. C., August 1907.

[3] Stühlern. Central. fur Bakt. July 31st 1908.

In another series of 15 cases of enteric fever among natives, in which the disease was diagnosed bacteriologically, cultivations were made from the blood of 10, one cultivation from each case. The stages of the disease at which blood was taken in these 10 cases varied from the 1st to the 3rd week. Typhoid bacilli were found in 5, and B. paratyphosus A. in one, which gives 60 per cent. Of the 4 cases in which cultivations from the blood gave negative results, typhoid bacilli were subsequently isolated from the faeces of 3, and the 4th gave a Widal reaction 1 in 400 on B. typhosus. In all the 5 remaining cases in which no attempt was made to cultivate from the blood, typhoid bacilli were isolated either from their faeces or urine.

We know that fresh-drawn blood quickly kills off typhoid and paratyphoid bacilli, and we also know that this bactericidal power is increased during an attack of the disease. With the knowledge of these facts we are justified in drawing the inference that the bacilli are being killed off in the blood during the whole of the febrile period. The increased bactericidal power of the blood would account for the fewer positive results from blood cultures during the later stages of the disease, and also for the dimunition in the number of bacilli found as the disease progresses.

The bacilli are sometimes found in the lungs, and may give rise to bronchitis, or other symptoms. On this account the expectoration from an enteric patient may convey infection. Bacilli are invariably present in the rose spots, and sometimes in many other regions of the body. The fact of the disease being a bacteraemia would lead one to expect to find the causal agent at times anywhere in the body, as for example in post-typhoidal abscesses, etc.

When the causal agent continues to multiply in the gall-bladder, or urinary passages after convalescence, the case becomes a "Bacillus Carrier."

(*B*) *During Convalescence.*

As soon as the acute clinical symptoms begin to subside, and the temperature approaches normal, the bacilli disappear from the blood, and convalescence sets in, unless it is interfered with by complications or a relapse. A fresh invasion of the blood takes place in relapses.

In the great majority of cases, shortly after convalescence has been established, the patient is free from infection, and no longer a source of danger to others, or a focus from which infection may spread. In a certain proportion of cases, however, the result is not quite so satisfactory, for it has now been proved that the infection may continue to cultivate itself in the biliary and urinary passages during convalescence, and in a smaller proportion of cases it may continue to do so for weeks, months, or years after the convalescent stage has been passed. The latter are known as "bacilli carriers." It is evident from this, and from the fact that post-typhoidal abscesses due to the typhoid bacillus sometimes occur, that recovery from enteric fever does not necessarily mean destruction of all the bacilli in the body.

Towards the end of an attack of enteric fever, and during the early stages of convalescence, the bactericidal power of the blood is high, but whether recovery is due to this factor alone has not been proved. That there are other factors concerned would seem to be indicated by what takes place in relapses, *viz.*, a fresh invasion of the blood notwithstanding its high bactericidal power. Possibly the opsonic content of the blood is a factor of importance, but as yet we are not in a position to dogmatise on what actually determines the initiation of a recovery.

It is important to remember that during the later stages of enteric fever, and during convalescence, the bacilli may be present in the urine in enormous numbers. As many as 100,000,000 per c.c. were found in the urine of a convalescing patient examined at the Central Research Institute, Kasauli; and several times in the same patient, and in other chronic carriers in which daily bacteriological examinations of the urine were carried out, the numbers often varied from 1,000,000 to 90,000,000 per c.c. As urine is a suitable medium for typhoid bacilli to multiply in these enormous numbers are easily accounted for.

(*C*) *Bacilli Carriers.*

Remlinger and Sneider[1] in 1897 drew attention to the fact that the typhoid bacillus may sometimes be present in the intestinal discharges of healthy people; but it is to Koch and to those who continued his work that we are indebted for scientific proof on the subject of bacilli carriers, and the part they play in acting as store-houses of the virus and sources of infection.

Bacilli carriers are recruited from two classes of the community:

1. A percentage of persons who have passed through an attack of enteric fever, but who still continue to harbour infection and excrete it in their faeces or urine.
2. In addition to those who have passed through a recognisable attack of enteric fever, there are others who may harbour infection and excrete it in their faeces or urine without ever having been attacked by the disease in a clinically recognisable form. Persons of this class are recruited from those who have been in close contact with the disease, or who have lived under conditions where infection is possible.

The Germans make a distinction between acute (or temporary) and chronic carriers.

1. Acute or temporary carriers, are those who

[1] Remlinger and Sneider, Annales de l'Institute Pasteur, January 1897.

harbour infection for a few weeks only, and in the case of convalescent enteric patients for a period up to 6 weeks after convalescence has been established.

2. Chronic carriers are those who harbour infection for months, or years, and in the case of enteric convalescents for periods longer than 6 weeks after convalescence has been established.

In both classes the gall-bladder and urinary passages are the sources from which the infection is derived, and in these situations it finds suitable media in which to survive and multiply. The infection of the biliary and urinary passages does not depend upon the type of the disease. The mildest types of enteric fever are just as likely to give rise to bacilli carriers as the severest forms of the disease.

In the great majority of bacilli carriers the absence of any symptoms pointing to their condition renders their detection impossible, except by means of a careful and skilled bacteriological examination of the faeces and urine, and this may have to be carried out daily and for a prolonged period before any reliable conclusion can be arrived at.

An important fact about chronic carriers is the intermittent character of the excretion of infection. In a number of cases in which the urine and faeces were examined daily and for prolonged periods at the Central Research Institute, Kasauli, the longest interval in the faeces was 75 days, and in the urine 31 days. In several of the cases examined the faeces were free from infection for periods varying from a few days up to one or two months or even longer, and the urine from a few days up to 2—3 weeks. In others the urine or faeces were infected for a week or 10 days without an interval. The bacilli are not found in the blood, and the agglutination reaction of the serum gives no reliable index as to whether they are carriers or not. Any ordinary sanitary enquiry would fail to detect such persons.

Gall-bladder symptoms are said to be an index in some cases. This is due to the fact that a typhoid infection of the gall-bladder may give rise to a condition favourable for the formation of gall stones. It would be well to examine bacteriologically the faeces and urine of patients suffering from gall-bladder symptoms after an attack of enteric fever, and in case a surgical operation on the gall-bladder was deemed necessary, a cultivation should be made from the contents in order to prove whether typhoid bacilli were present.

It is unfortunate that the detection of bacilli carriers is so difficult, and still more unfortunate that these difficulties are increased on account of the intermittent discharge of the infection in the faeces and urine. It is very evident that little or no reliance can be placed on the negative results of one or several examinations in arriving at a conclusion as to whether suspected persons are free from infection or not. It is difficult to know what should be considered a safe "bacilli free" period before allowing a convalescent enteric patient to mix with the general community, or to take part in the preparation or handling of food and milk supplies. That they can cause and have caused outbreaks of the disease in many instances has now been proved beyond all reasonable doubt, but whether they are a fruitful source of infection, or not, depends altogether on the facilities they may have for infecting food, milk, or drink supplies, or coming into contact with susceptible persons. A bacillus carrier in charge of a kitchen, dairy, or bakery, is a much more dangerous person than a carrier who has nothing to do with the preparation of food or milk.

As the existence of "chronic carriers" is but a recent discovery, and not as yet sufficiently investigated, it is too soon to say with any degree of accuracy what proportion of enteric patients drift into this condition. It is said that more females than males become carriers.[1] Ledingham gives the proportion of 3 to 1. As regards the proportion of enteric convalescents who become carriers, Klinger mentions 1·7 per cent. and Lentz 4 per cent., other observers consider these figures too low.

During an examination of 86 convalescent enteric soldier patients at the Central Research Institute, Kasauli, in 1906-07, ten were found to be excreting the infection either in their faeces or urine for periods longer than six weeks after convalescence. This gives 11·6 per cent. of cases infective for more than 6 weeks after the disappearance of all symptoms. Some of these continued to excrete the bacilli in their faeces or urine for months. Two of them were followed up for a year after convalescence and found to be still infectious; these two cases may possibly go on for a number of years to come.

The detection of carriers is one of the most important problems in the campaign against enteric, and also the most difficult. It would hardly be practicable to make daily bacteriological examinations of the urine and faeces of all convalescent enteric patients for 2—3 months before discharging them from hospital. What is wanted is a quick and accurate method of detecting these cases, and, having detected them, a safe and practical method of rendering them permanently innocuous. The solution of these two problems will mark the next most important advance in the prevention of enteric fever.

IV. *Bacteriological Methods Employed in the Diagnosis of Enteric Fever.*

A diagnosis based on clinical methods alone would fail to distinguish between typhoid and paratyphoid infections, and, even without distinguishing between the causal agents, it could not be relied upon in mild and atypical cases.

[1] Ledingham, J. C. G. The Typhoid Carrier Problem. "British Medical Journal," Oct. 17th, 1908.

An accurate diagnosis of any febrile condition enables us to say with certainty what is the causal agent, and in order to do this we are obliged in the majority of cases to have recourse to bacteriological methods.

The methods which have proved of most practical value in persons suspected to be suffering from enteric fever are blood cultures, and the serum test, both of which are easy of application, and may be had recourse to by any medical man with a knowledge of bacteriological technique. In a few cases it may be necessary to fall back upon examination of the faeces and urine, and in P. M. cases it is sometimes necessary to prove or disprove a doubtful diagnosis by making cultivations from the gall-bladder, spleen, and other internal organs. In the detection of bacilli carriers it is necessary to carefully and repeatedly examine the faeces and urine, but, as a routine method of diagnosing the disease during the febrile period, it has only been successful in from 20 per cent. to 30 per cent. of the cases.

The uncertainty of finding the bacilli in the faeces and urine depends on the following facts:

1. Enteric fever is a septicaemia, and infections of the biliary and urinary passages are secondary lesions.
2. The intestinal contents are known to form a very unfavourable medium for the typhoid bacillus. The bacilli do not multiply in the intestinal tract, but, on the contrary, perish there.
3. The urine is only infected in about 25 per cent. of cases, and then not as a rule until after the 2nd week of the disease.

When we take these facts into consideration, it is not to be wondered at that blood examinations have taken the place of examinations of the faeces and urine as routine measures in diagnosing enteric. Practically speaking, a bacteriological diagnosis of enteric fever means a cultivation from the blood. Widal's serum test, or both.

(1) *Blood Cultures.*

Within the past few years cultivations from the blood of enteric fever patients have been freely made use of, and prominently brought to notice as a means of early diagnosis. In many cases the virus is present in the blood before Widal's reaction appears, and, in addition, it has the advantage, when a positive result is obtained, of differentiating the causal agent.

Higher percentages of positive results are obtained during the 1st and 2nd weeks of the fever, which shows that the septicæmia is at its height early in the disease, and becomes less and less marked as the disease progresses. 90 per cent. of positive results have been obtained during the 1st week, fewer during the 2nd week, and fewer still as the disease advances.

It is early in the disease that a diagnostic test is most required because Widal's reaction is then often negative and one has to remember that pending a diagnosis the dangers of contact infection have to be reckoned with. A positive result may however be obtained at any time during the fever period, but rarely towards the end of the disease when the temperature falls to normal.

The media employed in making cultivations from the blood are numerous and varied, and several have given good results in the hands of competent observers. The best results up to the present have been obtained by using Conradi's [1] medium, which is ox bile, *plus* 10 per cent. glycerine and 10 per cent. peptone. Kayser[2] subsequently demonstrated that pure ox bile alone gave quite as good results as Conradi's medium.

Epstein[3] claims to have obtained a higher percentage of positive results with any one of the following media: 2 per cent. Glucose bouillon; 2 per cent. Glucose agar; 0.2 per cent. Ammonium oxalate solution. The reaction of these media requires to be about 0·9 per cent. Acid to Phenolphthalein. One or other of the media mentioned above has gradually replaced plain bouillon which was formerly used.

The special advantages of the bile media are supposed to be their inhibitory action on the coagulation of the blood, and the consequent preventive action of its bactericidal powers, also the influence of the bile salts in retarding the growth of certain other bacteria. It would appear from Epstein's experience that these supposed advantages have been greatly exaggerated. From the fact that it is possible in many cases to obtain a growth from the clot after the removal of the serum for Widal's reaction, it would appear that the inhibitory action of coagulation is not such a drawback as we formerly thought.

My experience has mainly been with Conradi's bile medium.

Into a small flask, bottle, or large test tube containing 20 or 30 c.c. of the bile medium, is inoculated a few c.c. of blood drawn off by means of a sterile syringe and under aseptic precautions from a vein of the arm in front of the elbow, generally the medium basilic. One c.c., or even a few drops of blood, would be quite enough in many cases, but it is just as well to draw off 3—4 or 5 c.c. and this amount is recommended as a routine measure. Another method which is said to be quite as satisfactory, and is easily carried out, is to prick the lobe of the ear, and allow a few drops of blood to fall into a test tube containing whatever medium is used. After incubating from 16 to 24 hours at a temperature between 30 and 37° C. the few bacilli present in the blood multiply rapidly, and when a subculture is made on to agar or Drigalski-Conradi plates, a pure culture is obtained in

[1] Conradi. Deutch. Med. Wochen. 1906, No. 2, page 58.
[2] Kayser. Munch. Med. Wochen. 1906, page 823.
[3] Epstein. American Journal of Medical Sciences, August 1908.

cases yielding positive results. It is difficult to detect or stain the bacilli in a bile glycerine medium, and on this account it is necessary to subculture on to ordinary agar, or Drigalski-Conradi medium, the latter for choice. When a growth takes place on either of these media, it remains to be proved whether it is typhoid, paratyphoid, or one of the allied groups, and for this purpose the usual tests for the differentiation of these micro-organisms are applicable.

The advantage of subculturing on to Drigalski-Conradi plates is, that the colonies of typhoid and paratyphoid have a characteristic appearance on this medium, and are easily detected for further test purposes. One of the most useful tests at this stage is the serum test. A colony from a Drigalski-Conradi plate, giving the delicate clear bluish shining appearance of a typhoid or paratyphoid colony, can be easily picked out with a platinum needle, and mixed on a glass slide with a high titre specific serum in a suitable dilution, when a clumping reaction immediately takes place, which may be visible to the naked eye, or can be rendered visible by means of a hand lens, or by a microscope. At the same time one could test for motility, and stain a specimen. A motile bacillus, not retaining the stain when treated by Gram's method, giving a colony on Drigalski-Conradi medium, presenting the characters above described, and reacting to a specific serum, is sufficient for a quick diagnosis.

In case further proof was considered necessary, the other tests used in differentiating typhoid paratyphoid, and their allies could be carried out from subcultures made from colonies responding to the initial tests. The results of blood cultures made by numerous observers on the lines described have given a percentage of positive results during the 1st and 2nd weeks of the fever varying from 80 to 90 per cent., and at later stages diminishing percentages, until the bacilli finally disappear shortly before or about the time convalescence sets in.

(2) *Widal's Reaction.*

This test requires no special description, as it is now almost universally used by every medical man who is called upon to diagnose and treat cases of enteric fever.

It is very often not found during the 1st week of the disease, and may be absent during the 2nd, and even the 3rd week. In exceptional cases it may not appear until convalescence sets in, and in atypical cases it may not appear at all.

In a case of typhoid infection the serum may also agglutinate paratyphoid bacilli (a group reaction); but as a rule the serum reacts in higher dilutions on the causal micro-organisms than on the allied groups. To this rule there are exceptions, and it is in these exceptional cases that cultivations obtained from the blood make clear the nature of the infection.

The serum from some cases of pneumococci infections, and jaundice have also been known to give a marked reaction on typhoid bacilli. Jaundice cases which react to typhoid may possibly be due to cholocystitis, depending on an infection of the gall-bladder with typhoid bacilli. Another fact to remember when applying the serum test to a person suffering from an illness more or less resembling enteric, is, that the blood of those who have been inoculated or who have had an attack of enteric may give a well marked Widal reaction for a variable time.

Notwithstanding these pitfalls, and others which might be mentioned, such as an unreliable test culture, the fact remains that in Widal's reaction properly carried out, and properly interpreted, we have an accurate method of diagnosis in the great majority of cases at some period or other of the fever especially during the later stages of the disease, when blood cultures are mostly negative. In blood cultures combined with Widal's reaction we have accurate means of diagnosing enteric in almost every case. The former is most useful during the first week before Widal's reaction is obtainable, and the latter during the later stages of the disease when the bacilli are no longer present in the blood. A combination of these two methods would seldom if ever fail in arriving at an accurate diagnosis.

(3) *Cultivations from the Fæces and Urine.*

The infection is seldom found in the fæces and urine early in the disease, and on this account cultivations from these sources are but seldom employed as a routine measure in the diagnosis of enteric. They are, however, indispensable in the detection of bacilli carriers, and as a means of proving whether a convalescent enteric patient is free from infection or not.

(*A*) *Urine.*—It is only necessary to spread a small quantity of the urine varying from a few drops to 1c.c. or thereabouts over the surface of a Drigalski-Conradi plate, and incubate at 37° C. for 18 or 24 hours. Any colonies presenting the characteristic appearance of typhoid or paratyphoid colonies are carefully examined, and the usual tests applied.

(B) *Faeces.*—The examination of the fæces requires more time, patience, and experience than that of the urine. Samples should be obtained as fresh as possible, and cultivations made without any unnecessary delay.

A very good medium to use is the Drigalski-Conradi medium, but several other media have given good results, notably MacConkey's and Endo's. Conradi [1] has recently brought out a new medium for the detection of B. typhosus when present in small numbers. It consists of 3 per cent. agar to which is added Pikrinsare and Brilliant Grun Krystal extra rein (Hochst). Both are acid dyes. The

[1] Conradi. Munch. Med. Wochen. No. 29, July 21st, 1908.

former is used in a dilution of 1 in 15,000, and the latter in a dilution of 1 in 150,000. The degree of acidity of the agar must be 3 per cent. Conradi states that a combination of these two dyes in the proportion mentioned when added to agar furnishes a medium which does not prevent the growth of B. typhosus, but at the same time has a strong inhibitory action on the growth of other organisms. After incubation at 37° C. for 24 hours on this medium. B. typhosus appears as small round colonies with smooth edges and almost flat.

It is well to dilute the fæces before plating. A convenient method of doing this is to emulsify one or two grammes of fæcal matter in a conical glass vessel with 10 or 20 c.c. of sterile normal salt solution; when the emulsion has stood for about one hour, so as to allow the coarser particles to subside, a small quantity of supernatant fluid is pipetted off for plating.

It is necessary to use three large Petri dish plates for each case. About 1 c.c. of the fluid emulsion is transferred to plate 1, and carefully spread over the surface with a glass rod spreader, bent at right angles. The same spreader, but without being reinfected, is then carefully rubbed in succession over the surface of plates 2 and 3; and all three plates are incubated at a temperature of 37° C. for 16 to 24 hours.

The next step is to search for colonies resembling typhoid or paratyphoid, and when these are found apply the usual tests.

The whole process is very easily carried out, but it requires considerable practice before one is able to detect readily the colonies with accuracy. It is very easy to miss a few typhoid or paratyphoid colonies mixed up with a rich growth of other bacteria found in faeces. On the Drigalski-Conradi medium B. Coli colonies are easily distinguished by their reddish appearance, and opaque thick growth. Typhoid and paratyphoid colonies present a delicate bluish transparent shining appearance, and are generally small for a 24 hours' growth. The first plate is often useless on account of the rich, even growth which covers the whole surface. Nos. 2 and 3 plates are seldom if ever so crowded as No. 1. The colonies on these two plates, especially those on No. 3, are generally well isolated, and can be examined and tested without difficulty.

(4) *Cultivations from the gall-bladder or other internal organs after death.*

No special description is required. Media similar to those employed in isolating the bacillus from the blood can be used. As regards the bile, it is only necessary to withdraw a little of this fluid from the gall-bladder, and spread it over Drigalski-Conradi plates in the usual way.

A portion of the spleen, liver, or kidneys might be emulsified in Normal Salt solution, and directly smeared over Drigalski-Conradi plates; or a small portion could first of all be transferred to Conradi's bile medium, and after incubating for 24 hours at 37° C. subcultures can be made as already described in the case of isolating the bacillus from the blood. A pure growth can often be obtained by smearing a small portion of the spleen over an ordinary agar slope.

V. *Sources of Infection.*

The basal fact which underlies the etiology of enteric fever may be described as twofold, *viz*; (*a*) man is the store-house of the infection, and (*b*) every case of enteric fever is a focus from which infection may be conveyed to others.

When we follow up the subject a little further we find that persons who harbour infection may be divided into four classes:—

1. Persons suffering from enteric fever, diagnosed and treated as such.
2. Persons suffering from enteric fever, but not diagnosed or treated as such. This class would include mild attacks in which the true nature of the disease was not suspected, and possibly many cases diagnosed and treated as ordinary diarrhoea, or simple continued fever.
3. Convalescent enteric patients who become "bacilli carriers."
4. Healthy persons who have never so far as we know passed through an attack of the disease, such as attendants on enteric fever patients, or persons who have been subjected to the same opportunities of infection as those who contracted the disease, probably temporary harbourers of infection, infective but not infected, in the ordinary sense of the term.

Of these 4 classes, class 1 is the least dangerous, on account of the disease having been diagnosed, and the dangers of infection recognised. The remaining three classes may be looked upon as the real propagators of the disease in India, owing to the fact that they may pursue their usual vocations in life without ever being suspected of conveying infection. Looking at the subject from these points of view, we see the importance to be attached to accurate methods of diagnosis; to "Chronic Carriers"; and to those who live under conditions where infection may be expected.

A slight and unrecognised case of enteric is a most dangerous person. In 30 cases of mild pyrexia, or what would be looked upon as "simple continued fever." Biffi and Galli[1] isolated Eberth's bacillus from the blood of 27. It is evident from this that many cases of so called "simple continued fever" are in reality cases of unrecognised enteric fever. A prolonged examination of the faeces and urine of 4 enteric fever attendants made at the Central Research Institute, Kasauli, revealed the fact that two of them were excreting typhoid bacilli in their faeces. Both were healthy men with no history of

[1] Biffi and Galli quoted by Birt, R. A. M. C. Journal, August 1907.

enteric. During the same investigation typhoid bacilli were isolated from the faeces of a healthy soldier who had acted as an enteric fever attendant some two or three years previously. In the case of another soldier who had only been in Hospital for a few days with a slight fever, not diagnosed enteric, and whose serum gave a negative Widal reaction, typhoid bacilli were isolated from his faeces a few days after his discharge from Hospital.

From facts such as these, it is only reasonable to conclude that, in European regiments and amongst the European population in India, there must be a number of persons acting as reservoirs for the typhoid bacillus.

Park[1] in a recent article on typhoid bacilli carriers, states, "As the majority of typhoid cases occur before the age of 30, the average life of bacilli carriers is fully 25 years, so that we have the somewhat appalling fact that there are half as many recovered typhoid cases who are typhoid carriers as there are typhoid cases in one year; and besides there are the typhoid carriers who have never had enteric fever."

Klinger (quoted by Park) examined the faeces of 1,700 healthy individuals who had never been known to have had typhoid, and found 11 of them to harbour typhoid bacilli.

In a search for the source of enteric fever in Indian cantonments we have food for reflection in these statements.

VI. *Channels of Infection.*

In epidemics of enteric fever some common source of food, drink, milk, or water supply becomes infected, and a large number of people contract the disease about the same time.

In endemic cases contact infection plays the most prominent part, and next in importance comes the contamination of food, drink, and milk supplies. Of these food and drink substances, milk is perhaps the most important, and water for drinking or domestic purposes in India is of secondary importance.

When we recognise man as the source of infection it requires no great stretch of the imagination to picture to ourselves how the germs from the secretions and excretions of infected persons may gain an entrance by any of the channels mentioned to the intestinal tract of healthy persons.

The opportunities for spreading infection are numerous in the case of harbourers of infection who have anything to do with the preparation or handling of food, milk, or drink supplies. Cooks, bakers and dairy men who happen to be "bacilli carriers" are perhaps the most dangerous people of all on account of the opportunities they have of handling media suitable for the dissemination of infection.

In the published records of many outbreaks of enteric in Germany, England, and America, in which the evidence was based on the results of scientific investigation, the sources of infection have been traced to carriers, some of whom had acted either as cooks, bakers, or who had attended in various capacities to food or milk supplies.

Evidence of this class in the support of chronic carriers as sources of infection is increasing daily. A certain amount of evidence on the subject was collected in India during a recent investigation of enteric fever at the Central Research Institute, Kasauli[1].

The following examples taken from the report on the investigation referred to will serve to illustrate what is no doubt constantly happening in every cantonment in India.

1. In August 1907, a small outbreak of enteric fever occurring in a detachment of the Bedfordshire Regiment stationed at Kasauli was traced to a carrier who acted as cook to the section in which the outbreak occurred. Five men of the section became ill about the same time. The bacillus typhosus was isolated from the blood of 4 of them. On the 31st July, immediately before becoming ill, the fifth man was transferred to Jhansi, and admitted to the Station Hospital for enteric fever, which he certainly contracted at Kasauli.

   A bacteriological examination of the blood, urine, and fæces of all the cooks and all the "contacts" in the unit was made, with the result that one of the cooks (Pte. W.) was found to be excreting typhoid bacilli in his fæces in large numbers. When this man was segregated no other cases of enteric occurred in the unit, and the disease did not extend to the other units. His health was perfect, and he had no signs of disease. The agglutinating reaction of his serum was 1 in 20, which is not higher than what is often found in normal persons. He had never acted as an enteric fever orderly. His medical history sheet showed no entry for enteric fever, but he had 4 admissions to hospital for other diseases, *viz.*, two for ague, one for abscess, and one for conjunctivitis. One of the admissions for ague was in December 1897, it was described as "severe," and he was in hospital for 70 days. The other admission for ague was in October 1900; it was described as "mild" and he was in hospital for 20 days. The 70 days in hospital for ague may have been an unrecognised attack of enteric fever; and if this was the case he had been a bacilli carrier for nearly 10 years.

2. In July 1906, a boy (Joseph T.) was admitted from the married quarters to the Station Hos-

[1] Park. Journal of American Med. Association, September 19th

[1] Scientific Memoirs of the officers of the Medical and Sanitary Department of the Government of India No. 32.

pital, Kasauli, suffering from enteric fever and later on in the month his next door neighbour, Mrs. C., was also admitted for enteric fever. In both cases the bacillus typhosus was recovered from the faeces.

In order to trace the source of these two cases, the blood, urine, and fæces of all the members of the T. family were examined with the result that Mrs. T., the mother of boy T. was found to be excreting typhoid bacilli in her fæces. She had been in close contact with her son, and on terms of very intimate relationship with Mrs. C., her next door neighbour. Mrs. T.'s serum agglutinated B. typhosus 1 in 80, her health was good, she had never passed through a typical attack of enteric fever, but about two months previously she had suffered from diarrhoea and fever for a few days only. There can be little doubt that Mrs. T. infected her son, and very probably her next door neighbour, Mrs. C., who lived under the same roof and was a frequent visitor to Mrs. T.'s quarters.

3. In examining a large number of healthy soldiers at Meerut, one man of the Scottish Rifles was found to be excreting typhoid bacilli in his fæces. He had no history of enteric fever, but had acted as an enteric fever orderly two years previously. Seven out of the ten cases of acute enteric fever examined at Meerut came from the unit to which this man belonged. It was not possible to establish any closer relationship between this carrier and the seven cases of enteric other than that they belonged to the same unit.
4. An epidemic of 12 cases of enteric fever at the Girls' Convent School, Poona, was traced to a Goanese cook who passed through an unrecognised attack of the disease, and at the same time continued to act as cook for the school until he became too ill to do his work, and proceeded on leave on the 3rd July 1907. Between the 21st and 28th July, five cases of enteric occurred in the school. The cook returned to his work on the 30th July, and between the 11th and 22nd August seven more cases of enteric occurred in the school, and after this there were no more cases.

His blood was examined for the first time on the 5th September, when the serum reacted on B. typhosus 1 in 100. On the 8th October his serum gave a positive Widal reaction 1 in 10,000. He was then in the Sassoon Hospital, Poona, suffering from symptoms pointing to an affection of the gall-bladder. Several bacteriological examinations of his urine and faeces failed to find typhoid bacilli. He was evidently a source of infection during his illness in June, and early in July, before going on leave, and also during convalescence when he returned from leave on the 30th July; but whether he became a "chronic carrier" was never proved beyond the suspicion attaching to the gall-bladder symptoms. His subsequent history could not be traced as he returned to his home in Goa.

Much has been written and talked about infection by flies and dust. Under ordinary conditions of life it is questionable whether these agents account for even a small percentage of cases. In crowded camps and where the disposal of infected excreta and other sanitary measures are difficult to carry out, flies may account for many cases. Typhoid bacilli have been isolated from the bodies and excreta of flies several hours after they had settled on experimentally infected material; so it is only reasonable to infer that after settling on excreta or urine containing typhoid bacilli under natural conditions, they are capable of transferring infection to food, water, milk, or utensils with which they come in contact soon afterwards.

Klein[1] has recently demonstrated the presence of a bacillus indistinguishable from the typhoid bacillus in the bodies of flies captured in the vicinity of a row of houses where a number of cases of typhoid made their appearance after the occurrence of a case which appeared in one of the adjoining houses; all other known channels of transmission were said to be excluded. He remarks "The only condition common to all the houses of the row was this, that they were swarming with flies."

Once an epidemic is set in motion, it is the usual experience that it is followed by isolated cases principally due to contact infection; each new case being a focus from which infection may be conveyed either directly or indirectly to susceptible persons.

VII. *Methods of Prevention based on the Life History of the Causal Micro-organisms.*

It is generally believed that the common factors which influence the spread of enteric fever in a community of people are imperfect provision for the disposal of their excrement, and a faulty water supply.

If we were to look upon these two items as the only factors implicated in the spread of enteric, the remedy to wipe out the disease would appear to be comparatively easy, *viz.*, a scientific method of sewage disposal, and a pure water supply.

These much-to-be-desired sanitary measures have no doubt diminished the incidence of enteric fever in many places where they have been tried, but they certainly have not succeeded in wiping it out. Both are very important not only in the prevention of enteric, but also in the prevention of cholera and dysentery, and for the following reasons.

We know that man is the store-house from which the virus of typhoid and cholera is derived, and

[1] Klein B. M. Journal, October 17th, 1908.

very probably also the only store-house for the causal agents of bacillary dysentery. The causal agents of these disease are shed into the external world in the faeces of infected persons, and in the case of enteric fever also in the urine; hence the importance of a perfect system of sewage disposal. We also know that a faulty system of water supply is likely to become contaminated with human excrement, and that epidemics of typhoid, cholera, and dysentery have originated from this source, especially cholera; hence the importance of a pure and safe water supply.

Granted a satisfactory solution of these two sanitary problems, what are the other channels which require to be guarded against in the prevention of enteric fever? As the answer to this question must take into account many of the facts already stated it may be as well to summarise a few of the most important.

The virus is dependent on infected persons for its existence, and if we except the possibility of some paratyphoid infections, it is not derived from any other source that we know of. By infected persons we mean, those who are suffering from an attack of enteric fever in some form or other, and those who are "bacilli carriers." The means by which infection is conveyed from man to man are numerous and varied. Indirect infection by means of food supplies, milk, and water, are the most usual channels in epidemics, but direct contact infection is a common source in crowded communities, and in those associated with infected persons, or attending on enteric fever patients.

According to Frosch,[2] the usual and permanent method by which endemic typhoid is propagated is by contact infection, which is greatly favoured by light and ambulatory cases, by "bacilli carriers," also by overcrowded and unhygienic dwellings, and uncleanly habits. Under the most favourable conditions the life of the typhoid bacillus in water or anywhere else outside the human body is comparatively short. Water-borne typhoid is of more frequent occurrence in European countries than in India, but, even in England, according to Seaton,[3] it only accounts for less than 10 per cent. of the cases. There are only some half a dozen cases on record where the presence of typhoid bacilli has been definitely proved in drinking water.

It is evident from these facts that any sound methods of prevention must take into account the sources from which the infection is derived, *viz.*, *the enteric fever patient*, and the "*bacilli carrier*."

Methods of prevention which fail to take these sources into consideration can only end in failure and disappointment. This is the most important fact upon which to concentrate preventive measures.

[2] Frosch. Proceedings of the XIVth International Congress for Hygiene and Demography. Berlin, September 1908.

[3] Seaton. Proceedings of Royal Society of Medicine, Vol. 1, No. 6, April 190[illegible].

1. *Enteric Fever Patients.*

A correct diagnosis based on modern methods of bacteriological technique is of primary importance. Mild and atypical cases can only be detected by bacteriological methods.

The recognition of the fact that every enteric patient is a source from which infection may be spread suggests isolation and disinfection of all the secretions, excretions and of everything worn or handled by the patient. It would also suggest the precautions to be taken by sick attendants to avoid contact infection either as regards themselves or others coming in contact with the patient. Care should be taken that infection from an enteric patient should have no opportunities of directly or indirectly contaminating food, milk, or water supplies It is important to remember that at times the germ may be excreted in the urine and faeces in enormous numbers, and that the urine may be a rich culture containing as many as 100,000,000 bacilli per c.c. This would mean that a single drop of the urine might contain as many as 5,000,000 bacilli. In conditions of this kind, and where the patient is not isolated, and no precautions are taken to disinfect the excretions, we can well imagine what a fruitful source of infection such a patient might become. It would be an advantage to have all cases treated in hospitals and quite separate from other patients. Nurses and sick attendants should be well instructed in methods of disinfection, and the attending physician should satisfy himself that they thoroughly understand this part of their duty and the rationale upon which it is based.

Before discharging convalescent patients from hospital or the sick room, steps should be taken to ascertain whether they are free from infection, and any who may be found to be still excreting the virus in their faeces or urine should be retained for a further period until a definite conclusion shall have been arrived at as to whether they have become bacilli carriers.

In the practical application of these recommendations to enteric convalescents before discharging them from hospital, we are met at the onset by two prominent difficulties:—

1. The possibility of having to carry out a daily bacteriological examination of the faeces and urine for a prolonged period before being able to give an opinion as to whether a typhoid convalescent is free from infection or not.
2. When a bacillus carrier is detected, the difficulty of dealing with the case so as to safeguard other persons from infection.

A practical solution of these two difficulties is urgently required. Until they have been overcome we are obliged to have recourse to our present tedious methods of detecting harbourers of infection, and when they are detected, we can only deal with them by the application of general principles of prevention.

2. *Bacilli Carriers.*

As yet there are no thoroughly practical and satisfactory methods of dealing with this source of infection.

The facts already mentioned about bacilli carriers will enable us to understand why the problem is beset with so many difficulties. The intermittent character of the excretion of the bacillus in the urine and fæces is the one item which renders their detection a matter of time and patience. In order to detect bacilli carriers as early in their career as possible, and before they have had opportunities of spreading infection, it will be necessary to exercise a prolonged supervision over enteric convalescents, the class from which the great majority of carriers is derived. It would not be safe to base an opinion on a few examinations giving negative results, hence the necessity for repeated bacteriological examinations of the urine and fæces of enteric patients after a clinical cure has been pronounced.

When carriers are found, their condition should be explained to them, and they should be warned of the importance of cleanly habits. Disinfection of their excretions should be insisted on, and on no account should they be employed in the sale of food stuffs or have anything to do with the preparation or handling of food, milk, or drink supplies. In a word they should be debarred from any kind of work which gives them opportunities for infecting other people.

In those presenting symptoms of gall-bladder complications such as cholecystitis, or gall stones, a surgical operation would be indicated, and when the condition is due to a gall-bladder infection, a permanent cure is possible, either by removal of the gall-bladder, or washing it out with an antiseptic.

It will be seen from these observations that it is not yet possible to lay down practical rules for the management of bacilli carriers, other than rules which involve isolation, the inculcation of cleanly habits, disinfection of excretions, and the selection of employment which gives them no opportunities of infecting other people.

At present we know of no safe and reliable method by which a bacilli carrier can be freed from infection.

VIII. *Prophylactic Inoculation.*

This method of immunisation against typhoid fever was first introduced by Wright and Semple at Netley in 1896-07 and the principles upon which it is based were fully explained by them in the British Medical Journal of January 30th 1897 together with the result of the serum reactions in some 16 cases inoculated. Since then inoculation as a prophylactic measure has been extensively carried out in many countries, and is at present being carried out on an extensive scale in the British Army in India and the Colonies.

Within the past few years the subject has been so ably dealt with by Sir A. E. Wright in numerous publications by that author, and also by Leishman, Birt, and others, that there is no necessity to describe what is now a well-known preventive measure. A few remarks about the vaccine employed may, however, be of interest.

The vaccine consists of a sterilised pure culture of typhoid bacilli, carefully standardised and an antiseptic added to prevent subsequent contamination. Either an agar or bouillon culture of B. typhosus can be used; the Germans prefer the former, but most of the inoculations in England and India have been carried out by the latter; equally good results can be obtained by either. When an agar culture is used the vaccine is prepared from a 24 hours' growth; and from a 24 or 48 hours' growth when a bouillon culture is used. The vaccine is standardised by counting the number of bacilli in a measured quantity after dilution in accordance with methods devised by Sir A. E. Wright.

The strain of B. typhosus used in the preparation of the vaccine is of more importance than its virulence. It is advisable to use a strain which has been proved by experiments on animals to be rich in haptophore groups or antigens.

A strain of this class, although not necessarily virulent, gives rise to a higher degree of immunity as evidenced by a larger amount of protective substances in the blood of men or animals upon which it is used than other strains which are poor in haptophore groups.

The usual method of sterilising the culture is by heating at a temperature of 60° C. for 20 minutes; or at a temperature of 63° C. for one hour (Leishman). After heating, an antiseptic such as carbolic acid 0·5 per cent., or lysol 0·25 per cent., or any other reliable antiseptic is added.

It was proved by the German Plague Commission when working at Bombay in 1898 that heating a vaccine after the addition of an antiseptic greatly diminishes its immunising properties and may remove them altogether.

In the sterilisation of an antityphoid vaccine there is no necessity to use heat, as typhoid bacili are killed in 0·5 per cent. carbolic acid within 24 hours. The vaccine prepared by me at the Central Research Institute, Kasauli, during the past two years has been sterilised by the addition of 0·5 per cent. carbolic acid only, and by this means the possible harmful effects of heating are avoided.

Experience has proved that the most convenient site for injecting the vaccine is on the front of the chest about 4 inches below the middle of the clavicle. The local effects give less trouble in this situation than anywhere else. Two inoculations are recommended. The interval allowed to elapse between the 1st and 2nd inoculations should be from 10 to

[1] Wright and Semple. British Medical Journal, January 30,1897.

14 days. The 1st dose should be regulated so as to produce a sufficient response without giving rise to a prolonged or marked negative phase, and when this has been accomplished, the 2nd dose should be $1\frac{1}{2}$ times or double the first.

When the dosage and interspacing have been regulated on these lines, a higher and more lasting degree of immunity is conferred.

The most important points about the preparation and administration of an antityphoid vaccine are the following:—

1. A well selected and reliable strain of B. typhosus should be used.
2. Absolute sterility and accurate standardisation are essential.
3. Appropriate dosage and appropriate interspacing are also essential.
4. Like most other vaccines antityphoid vaccine is liable to deteriorate when kept for longer than a year after being made up. Exposure to light and a high temperature are factors which hasten deterioration. The method of sterilisation employed and the kind of antiseptic added are very important factors in preserving the immunising properties of a vaccine. Carbolic acid to the extent of 0·5 per cent. is the best antiseptic to add.

The benefits of antityphoid inoculation may be summarised in a few words.

1. The incidence of the disease in the inoculated is 4 or 5 times less than in the uninoculated.
2. Should the disease be contracted after inoculation the attack is generally mild and the death-rate less than in those not inoculated.

As a prophylactic measure it is strongly recommended for Europeans of the susceptible age-period before proceeding to countries where typhoid fever is endemic. It is especially applicable to young officers (Military and Civilian) and young soldiers on proceeding to India for their first tour of service and should be carried out shortly before or immediately on their arrival in the country.

TYPHOID FEVER IN TRAVANCORE.

By JAMES DAVIDSON, M.D. (EDIN.), ETC.,

Medical Officer, L. M. S., Hospital, Neyoor; late Senior Resident Medical Officer, Edinburgh Fever Hospital; House Surgeon, Stirling Royal Infirmary, etc.

For the last three years I have been in charge of the Neyoor Central Hospital and its 15 out-stations, and during that time have had ample opportunity of studying and comparing Typhoid Fever as seen in Travancore with what one sees of the malady in Scotland in a year's work as Resident Medical Officer of the Edinburgh Fever Hospital.

Roughly speaking, the difference does not seem to be very great. Perhaps it might be summed up in three distinct features, *viz.* :—

(1) *Absence or infrequency of Typhoid Spots.*

But who could expect this to be otherwise in a land where dark skins are prevalent and insect bites so common? (I refer to mosquito bites, and omit to mention even more objectionable creatures.)

(2) There seems to be a *higher mortality* in India than in the West.

(3) Our diagnosis is often rendered more difficult owing to the frequency of malarial fever, and other fevers which tend to assume a remittent type, and also owing to complications arising from the constant occurrence of coincident intestinal parasitic infection.

Now let us try to shortly review in some systematic fashion the subject of "Typhoid in Travancore" and I suppose that means "Typhoid in India"—for I do not know that we can claim any special features for the disease in the southern-most point of the Peninsula.

During the last three years we have treated 70 cases of typhoid fever in Neyoor Hospital, and, as I glance through the charts and notes (which are carefully preserved and bound), I find that the majority show fairly well the classical periods of gradual rise, of sustained temperature, and of gradual lysis.

Major Rogers, in his "Fevers in the Tropics" recently published, says regarding the period of rising temperature :—

"This stage especially differs in India from the classical step-like rise. Only a few cases came under observation during the earliest period of the disease, but out of 6 *cases* admitted during the *first* 2 *days* of fever none showed a gradual rise of temperature, but in each it had already risen to from 103° to 105° F."

My experience in Travancore hardly agrees with the foregoing. I have usually found the orthodox tendency to gradual daily increase of temperature except in cases where there has been what seemed to be a coincident malarial infection. Of this, I shall have more to say later on. I have had 8 *cases* which were first seen either on the *first*, *second*, *or third day* of these diseases. In three of these only was there what might be termed a sudden rise of temperature at the onset and 2 out of the 3 were clearly malarial subjects.

In the *other* 5 cases the daily rise of temperature was a gradual one.

COMPLICATIONS.

We find that the commonest, and also the most fatal complication in Travancore is Pneumonia. This was pre-

sent in 10 out of the 70 cases or 14%, which agrees very closely with Major Rogers' Calcutta series, *viz.*, 9·7%.

Bronchial Catarrh occurs very frequently, more than half of our cases showing signs of such involvement on physical examination.

The presence of the *Ascaris Lumbricoides* after a dose or two of Santonine was exhibited in 9% of our cases. We had no reason to believe, however, that perforation occurred more frequently on account of that parasites' presence, as we were able to record only one case of perforation following a hæmorrhage in the orthodox manner.

But in several cases where there was a continued fever very closely simulating typhoid fever, this has quite cleared up on giving Santonine, and many worms were passed, 54 being counted in one case.

In 5 of our 70 cases we met with Parotitis, which usually went on to suppuration in spite of treatment.

In only two cases could we record a hæmorrhage, but a number of serious cases were removed at a time when hæmorrhage might soon have occurred had they remained in Hospital for a longer period. For this same reason we have found it very difficult to accurately gauge our death-rate.

We have only had 7 deaths in Hospital from Typhoid during the last 3 years, or 10%, but many cases have been removed in a critical condition; and another 5% or 10% must be added on this account.

This compares favourably with Rogers' Calcutta series in which he records 16%, but Curschmann after 13 years' experience at Leipsic gives his mortality as 12·7 and Osler in 10 years at Baltimore only lost 7·5%.

While we have many cases of Abortive Typhoid in India, as elsewhere, I think the general experience will prove the same as ours in Travancore, *viz.*, that the hotter climate of the Tropics with its conseouent devitalizing effects leads to higher death-rate in Typhoid than that which is noted in the cooler climate of the West.

The more one sees of typhoid fever, whether it be in India or in the West, the more one is convinced that the treatment is nursing rather than medicinal. I feel inclined to agree with some one who remarked that the battle is usually fought out in the first week, or at any rate the fact of treatment on the one hand or the lack of it on the other, in most cases, determines whether the case will be a bad one or not.

Early diagnosis is more important, therefore, than treatment and I may be forgiven if I say but little about the latter, and devote some time to the consideration of the former.

I can dismiss the question of treatment in very few words.

TREATMENT OF TYPHOID FEVER.

As regards treatment I fear I have nothing new to offer. "How may we limit the destruction of tissue in the intestinal wall?" seems to be the great question. Many seem to regard the process of ulceration as inevitable and do nothing to try to prevent these lesions. Prevention of ulceration would mean, of course, prevention of hæmorrhage, and of perforation. Some have recommended the use of purgatives as being the best mode of elimination of the toxins. The effect is to carry out of the body the bile, which, as a result of the toxin-abstracting function of the liver, must be itself toxic to a large extent.

It certainly would seem to be the case that the battle is mostly lost or won during the first week of the disease. Hence the value of early diagnosis and treatment.

Probably the best line of treatment is a judicious combination of the purging and what might be called the intestinal antiseptic method. This latter line, however, I think, all who have treated many typhoid cases will concur, is somewhat disappointing. We have tried Salol, Calomel, Liq. Chlorine, etc., with more or less result, perhaps less rather than more. Lately we have been trying Iodine and Pot. Iodid.

Re Iodin.	... ..	gr. vi.	Sig. 3 drops
Pot. Iodide	...	gr. xii.	in water every
Aq. ad.	...	oz. ii.	2 hours.

In Scotland I was in the habit of employing irrigation largely. In India I have found Acetozone a valuable drug in the treatment of Typhoid.

DIAGNOSIS OF TYPHOID FEVER.

As regards early diagnosis probably none of the Indian fevers presents more difficulty than Typhoid. When once the symptoms in such cases are fully established, the clinical picture is usually an unmistakable one. But to make a diagnosis during the first week of the fever is often a very difficult matter. We are always glad, therefore, of any aids to diagnosis. There are three or four such which, I believe, have not gained the place that they deserve, *viz.*

(1) Erhlich's Diazo Urine reaction.
(2) Widal's serum test.
(3) Microscopic examination of blood films.
(4) Examination of abdominal reflex.

Let us briefly glance at these :—

(1) *Erhlich's Diazo Reaction in the Urine.*—The reaction depends on the fact that if Sulphanilic Acid (amido-sulpho-benzol) be acted on by Nitrous Acid, diazo-sulpho-benzol is formed. This last named unites with certain aromatic compounds occasionally present in the urine to form aniline colours. Two solutions are necessary :—

(*a*) Saturated solution of Sulphanilic Acid in 5 per cent. Hydrochloric Acid.

(*b*) ½ per cent. solution of Sodium Nitrite. Both solutions should be as fresh as possible.

Test.—Add to some urine in a test-tube an equal quantity of (*a*). Add two or three drops of (*b*), and shake till a froth forms. Render alkaline with ammonia. If the liquid becomes a *port wine* colour, while the froth is red or pink, the reaction is *positive*. Now what is the significance of the test ?

If the urine of a supposed typhoid case in the 2nd or 3rd week fails to give the reaction, the diagnosis is probably wrong. In very mild cases, however, the reaction may be absent. The reaction is also present in measles, typhus, and in tubercular disease which is spreading rapidly.

Budden gives an exhaustive account of his experience of the diazo reaction, *viz.*, in 3,000 patients, performing it many times in each. The list included 600 persons in health, no one of whom yielded a positive reaction. He therefore concludes that the reaction is never present in normal urine. It was found present in :—

96	out of	672	cases of various forms of tubercular disease.
18	,,	25	cases of measles.
17	,,	21	typhoid cases.
5	,,	5	typhus cases.
4	,,	41	pneumonia cases.
4	,,	4	cases of acute puerperal septicæmia.

The remainder, comprising almost every acute malady of common occurrence, yielded a negative result; excluding typhoid, measles, typhus, and puerperal septicæmia, every case which gave the reaction in the series proved to be the subject of tuberculosis. Dr. Ker (Edin. City Hospital) believes that during the 2nd week of typhoid, the diazo reaction is almost always present—sometimes even as early as the 5th day. He goes so far as to say that a case of continued fever, which at any time between the 6th and 12th days does not give the reaction, is in all probability not typhoid fever. He also found that the cases which reached hospital as early as the 5th or 6th day were invariably sent in by general practitioners who used the test.

(2) *Widal's Serum Test.*—For this well-known test one requires a fresh culture of typhoid bacilli (best not more than 24 hours old). Blood is taken from the patient who is suspected of typhoid in a small capillary tube or pipette. It is *preferable*, though not essential, to allow the clot to settle and only use the serum.

Various dilutions are made, and there are various methods of doing so. But 1–20 or 1–30 is perhaps the best dilution. A control experiment should always be made with the examiner's own blood, or with that of some one who is not suffering or has not recently suffered from typhoid.

Under ordinary high power of the microscope (300 or 400 diameters) the well-known clumping or agglutination of the bacilli is seen.

The reaction may also be obtained by employing dead cultures instead of a fresh one in bouillon. The bacilli are killed by heating the bouillon to 60° C. for an hour, or by adding one drop of formalin to every 150 drops of bouillon. The test is a *macroscopic* or naked-eye one ; for, on addition of serum from a patient who has typhoid fever, sedimentation occurs. The advantage of this form is that the test is at the disposal of the busy practitioner, who has no laboratory for the cultivation of living bacteria or who has but little time to spend in the laboratory he has.

Parke, Davis & Co. have taken advantage of the sedimentation form of test and have brought out what they call the "Agglutometer." I have given the instrument a fairly extensive trial both in Scotland and out here in India, and cannot say that the results have been very satisfactory. In clear cases of Typhoid—cases in which the clinical symptoms are typical—the reaction is usually well marked, but in doubtful cases, where one is *most* anxious to make a diagnosis, the reaction, I have found, is often doubtful. It would seem, however, that in these later days the bacillus of Eberth has lost its reputation to some extent, for Prof. Netter teaches us that the Agglutination Test often fails with the *bacillus typhosus* but is found with cultivations of the *bacillus coli communis* or other allied para-typhoid organisms.

(3) *Microscopic Examination of Stained Blood Films.*—Pœppelmann has pointed out that typhoid fever is not merely a local infection of the intestine, but it must be regarded as a septicæmia, which has its point of origin in the intestinal mucous membrane, and the bacilli seem to pass into the blood at an early date. Thin blood films are made and allowed to dry. They are placed for from 2-6 minutes in a cylindrical bottle containing R. May Gruenwald solution. (This is a methylene-blue-eosin mixture of somewhat similar composition to Jenner's blood stain.) The slides are transferred to distilled water for a minute and then rapidly dried. When examined with one-twelfth inch (oil immersion) lens, the typhoid bacilli are seen stained blue. The writer finds that blood taken before the temperature rises, *i.e.*, in the morning, gives more bacilli. In every case the organisms were seen at an early stage. The method is intended as a practical one for the practitioner, and does not require the preparation of cultures, etc.

We recently saw a patient who was suffering from typhoid fever, the Widal test being positive. She had had what was probably malaria in childhood and the typhoid chart showed signs of the old periodic fever. There were also some rigors. Films were taken and stained by both Romanowski and by the ordinary eosin and haematoxylin methods. No malarial parasites were found, but abundant typhoid bacilli were observed by us.

(4) *The Abdominal Reflex.*—Dr. Ker recently published an article in the *Practitioner* on the value of the absence of the superficial reflex as an aid to early diagnosis of Typhoid. He there remarked that only in Typhoid, Appendicitis, and certain central nervous system conditions was this reflex lost.

I saw a case a few weeks ago of what I took to be hemiplegia caused by embolism in a case of typhoid fever. The abdominal reflex in that case was entirely lost on the side of the hemiplegia and only partially so on the other side. Was the entire loss due to the lesion in the Central Nervous System, and the partial loss an expression of the return in the 4th week of typhoid fever? At any rate, this was our diagnosis.

Before leaving the subject of diagnosis allow me to

add our own experience to two of the foregoing clinical tests, *viz.* :—

(*a*) *Erhlich's Diazo Test.*—In 1894 Tull-Walsh carried out the test in a number of Typhoid and "remittent" fevers in Calcutta and came to the conclusion that it was of little diagnostic value.

Rogers states that the reaction is certainly frequently absent in early cases of Kala-azar as well as in malarial fevers, but data are not at hand to show the frequency with which it may occur in tropical fevers other than Typhoid.

Being not only familiar with the test at home, but having found it of great help in early diagnosis, I made a careful investigation into its usefulness in Travancore, but like the observer quoted above I have been disappointed; only in 25 per cent. of the cases in which we tried the test have we been successful, but we have recorded the fact that all the positive reactions were obtained between the 6th and 9th days of the disease.

In no case in which the urine was examined by this test after the 10th day did we obtain any positive reaction, even though the case proved by Widal's test to be clearly one of Typhoid.

(*b*) *Absence of Superficial abdominal reflex.*—In 93 per cent. of the cases of Typhoid in which we tested this reflex we found it to be absent.

In several cases we noticed that the reflex seems to return about the 3rd week of the disease. This, however, does not destroy the usefulness of its absence as an aid to diagnosis as the difficulty is always in the very earliest stages, when such an aid as this must prove valuable.

There is but one other subject to which I wish to refer, *viz.* :—

The so-called Typho-Malarial Fever.—Some years ago we read a good deal about "Typho-Malarial Fever" as if this was a specific disease—neither typhoid nor malarial, nor any of the other defined forms of continued fever. Manson believes that this fever is simply an ordinary typhoid occurring in a person who has been exposed to malarial influences, in fact, one who has been infected previously by the parasite.

Whether the germ can lie dormant for months or even years and then like the Tubercle Bacillus regain its activity on the occurrence of some severe physiological strain is not quite clear.

Clinically, however, this would appear to be so; and any persons who have had malaria at some period in their life, when they suffer from fever or disease of any kind in later life, find that this fever or disease tends to take on an intermittent or periodic character. There are few more depressing influences than typhoid fever. It is not surprising, therefore, that that fever in a patient who has previously suffered from malarial fever should show signs of the revival of the malarial infection. This then constitutes the much maligned typho-malarial fever, of which some deny even the existence.

In the case of a European young lady who was clearly suffering from typhoid (Widal positive, and all other symptoms typical) and who was showing by rigors some recrudescence of former malarial trouble, my colleague, who was attending the case, sent me films for examination. Unfortunately, Quinine Sulph. had been given prior to the taking of the films. No malarial parasites could be found, but abundant typhoid bacilli were seen when the films were examined under the microscope.

In the *Indian Medical Gazette* a recent observer has recorded the actual presence of the malarial parasite in the blood of a typhoid patient, and no doubt seems to remain regarding the possibility of double infection. I have had a good many cases of what I believe to be double infection in native patients, as malarial fever is exceedingly common on the malarial coasts. Clinically we may remark some differences from the ordinary typhoid. Instead of the slowly-increasing malaise and day by day step-like rise of temperature—so often seen in the West and so prettily depicted in the Charts of Wunderlich—the first recognized sign of typhoid here is often a violent rigor and a rapid rise of temperature. This may be repeated daily for the next two or three days, the remission becoming less complete each time.

In spite of Quinine the temperature may remain permanently high or the malarial manifestations may disappear and the case run an ordinary typhoid course.

The diagnosis between typhoid and some forms of malarial remittent fever is often exceedingly difficult. In fact it is practically impossible without the use of the microscope and the serum test.

The principal clinical points to be kept in view are :—

(1) *The mode of incidence of the disease.*

In typhoid there ought to be (apart from previous or coincident malarial infection) a gradual daily increase in the rise of temperature, a daily gain of a degree or so, during several days, as against a sharp rigor and sudden rise of temperature through 5 or 6 degrees in the first few hours of a malaria.

(2) *The gastric symptoms often differ.*

In malarial remittent there is bilious vomiting and perhaps diarrhœa, tenderness of liver, epigastrium and spleen. In contrast to this, in typhoid we have abdominal distention and perhaps iliac tenderness with gurgling, and it may be the "pea-soupy stools."

Such signs as epistaxis and deafness have a little diagnostic importance; but little or no aid, as we have already remarked, can be got from skin eruptions.

But in both typhoid and malarial remittent there is continued fever, lasting perhaps for weeks. In both there is a morning fall of temperature. There may be constipation in both. The spleen may be enlarged in both—probably more so in the malarial condition—but I confess that I have often been puzzled where the Widal has proved negative (perhaps because at too early a period) and the examination of a blood film has led to no definite conclusion.

Lately I have been experimenting along an entirely different line, and think that I have got some aid from

the method pursued, *viz:*—the estimation of the blood-pressure. When at the Edinburgh Fever Hospital, I had the opportunity of making careful sphygmometric observations in a number of cases of fever.

Routine examinations of the blood-pressure with various forms of instruments were made at the same hour each day in order that the readings might be as uniform as possible.

In certain special cases frequent readings were taken. From the readings so obtained—which in every case represented in mm. of Mercury the maximum systolic pressure—graphic charts were made out.

The results of some of these observations were given in the *Lancet*, October 17th, 1907.

In 37 cases of simple Scarlet Fever which I examined at that time I found that practically all showed the same curve of blood-pressure. It followed very closely the curve of the pulse-rate and that of the temperature, when these were represented graphically.

In one case, however, admitted into hospital as one of Scarlet Fever (and which happened to be one of the above series), the blood-pressure routine examinations showed that this was markedly sub-normal and as hypotension was not to be expected in such a case, suspicions of typhoid were aroused, and Widal's tests proved positive on first examination as well as on several later occasions. The value of the estimation of the blood-pressure was therefore exhibited, for by its means the diagnosis of a doubtful case was greatly aided. The remembrance of this clinical observation has led me to endeavour to try whether the estimation of the blood-pressure in typhoid and in malarial fevers did not furnish a means of distinguishing between the two.

Sphygmometry in clinical work has recently become very popular and many different forms of apparatus are now being advocated.

I have tried Hill and Barnard's Sphygmometer, Oliver's Hæmo lynamometer, Verdin's Sphygmometer Gaertner's Tonometer, &c.

Probably the best all-round instrument for clinical use is one of the recent modification of the Riva-Rocci instrument, such as Mummery's.

When at the Edinburgh City Hospital I made a good many observations of the blood-pressure of patients suffering from typhoid.

It is generally admitted by all observers that the blood-pressure is always lowered in this disease. Hypotension is the rule; though perforation or peritonitis tend to cause a rise in pressure. Increased tension is often found the day before a hæmorrhage. It may also accompany congestion of the lungs. Arterial tension would thus seem to be able to reveal the onset of complications and taken together with other clinical signs and symptoms is useful in prognosis. It is also a useful indication for therapeutics. For reduction of tension, vaso-dilators like spirits of nitrous ether are useful, but to raise the tension cardiac tonics are better than vaso-constrictors, as the latter may tend to increase the danger of hæmorrhage.

I have lately been making some observations on the blood-pressure of patients suffering from typhoid, remittent fever and intermittent fever.

I fear I have not yet gathered records of a sufficient number of cases to justify my being in any way dogmatic on the subject, but I have invariably noticed the hypotension of the pulse in true typhoids as contrasted with the hypertension seen in malarial cases. I believe sphygmometry, therefore, gives an additional aid to those who look for such as a clinical method of distinguishing between difficult cases of remittent fever.

Such then is a short summary of my experience of "Typhoid in Travancore." I fear there is but little new or original in what I have had to say, but I trust that some of the remarks may have proved not altogether devoid of interest.

Typhoid all the world over is a truly "Sporting" disease, for one can never proclaim one's patient quite "out of the wood" till the temperature has been normal for some time, but anything that enables us to diagnose at an early stage or to treat more successfully this fatal fever must come as a blessing to humanity.

DISCUSSION.

Khan Bahadur Dr. N. H. Choksy (Bombay), said :—I concur with Dr. Davidson as regards the differences observable in Typhoid fever in India. I would add two more to those he has laid down, *viz.*, absence of Diarrhœa in many cases, and a shorter course averaging about 14 days. The higher mortality is due to two factors :—

Firstly to lack of early diagnosis, and secondly to neglect of treatment together with injudicious dietary during the first week. The importance of the former must be sufficiently recognised ; Widal's reaction is the test generally employed at Bombay : it has given positive indications in a large percentage of cases : there exists however a small group presenting all the undoubted clinical features of the affection but with a negative re-action. Such cases have been tested simultaneously for paratyphoid and coli infection as also for infection with Gaërtner's bacillus but with negative results. The principal features that characterise the affection, as observed at the Arthur Road Hospital, among Indian patients consist in a gradually progressive temperature rising by step-like stages, attaining the maximum elevation during the middle of the second week, and declining with crisis on the fourteenth day. Iliac gurgling, the absence of diarrhœa and spots, the low muttering delirium together with a state of torpor, pneumonia or broncho-pneumonia and rapid cardiac failure just about or after the crisis are noticeable. Perforation is infrequent but relapses are not uncommon. All classes of Indian patients are liable to the infection. The treatment is mainly symptomatic inasmuch as intestinal antiseptics have not given the desired result. Observation elsewhere with the cyanide of mercury in gastro-enteric infections and its marked action in cholera impels me to suggest its use in typhoid fever. And moreover as it is now established that the bile in the gall-bladder is one of the media wherein the Eberth's bacillus continues to live after the patient recovers and is one of the sources of the persistence of the infection in the system among "typhoid carriers"—the other being the urinary passages—a preparation of this nature is clearly indicated. Of all the cardiac remedies for sustaining the action of the heart, the preparations of the suprarenal gland, adrenalin and renaglandin are the best. Urotropine is usually exhibited to all patients during convalescence as it is a preventive against "carriers." An absolutely milk diet is not always desirable and many patients do better without much or even any milk at all. Weak farinaceous preparations, thin soups, sanatogen or plasmon and whey or butter-milk have been found to be useful.

PARATYPHOID-B AS SECONDARY INFECTION.

By Dr. J. J. VAN LOGHEM, Priv.-docent, University, Amsterdam,

Temporary Director of the Pathological Institute, Medan, Sumatra.

In several papers at this Congress it is stated that Paratyphoid A and B bacilli can produce a disease resembling typhoid fever. This is the general opinion, but I will prove you that we have to be prudent before making the diagnosis of Paratyphoid, even when we cultivate the paratyphoid bacillus from the blood.

Paratyphoid bacilli can be present by *secondary invasion* in the blood as is shown in a case I saw with Dr. Van Hengel in the hospital of the Deli-Maatschappy in Medan.

I will not give you all the details of this complicated case; they will be published elsewhere; I will only remark that the patient showed all the clinical symptoms of true typhoid fever and that during the period of continued fever I cultivated Paratyphoid-B from the blood; the blood containing 21 colonies per c. c, (bile agar of Schuffner). On the same day Widal test 1,1000 was positive for typhoid and paratyphoid-B bacilli.

The case ended fatally and I found post mortem typical typhoid lesions of the organs. Cultivations from spleen and bile gave no trace of paratyphoid-B. In the organs typhoid-bacilli only were present.

This case can be considered as true typhoid-fever, although the cultivation during life from the blood gave paratyphoid-B only.

I do not think that my case is merely an exception, which is interesting for its rarity. The literature of paratyphoid-B in man often raised doubt about the true paratyphoid-B nature of many described cases.

There is another fact in pathology, which draws our attention to the secondary role of paratyphoid-B bacilli.

Hog cholera has been considered for years as a disease caused by the hog cholera bacillus, an organism belonging to the paratyphoid-B group. Researches in different parts of the world have now proved that this supposition is erroneous; that it is an invisible virus which causes the disease, that the paratyphoid-B bacilli is not present in all the cases or plays only a secondary roll.

In some experiments into a pig-disease we made in our laboratory in Sumatra we ascertained the same fact. Many pigs died after injection into filtrated serum of a sick animal; only one of them was invaded by paratyphoid-B bacilli; the organs of the others were sterile.

This disease in animals proves also that we have to be prudent in our conclusions, *even when we cultivate the paratyphoid-B bacillus from the blood and the organs.*

DISCUSSION.

Capt. Gordon Tucker, I.M.S., said:—The fact that individuals may be carriers of the typhoid bacillus over long periods is not only a matter of interest to the sanitarian but also to the clinician. We have known for a long time that the typhoid bacillus may be the cause of the formation of gall stones. Hence a history of a previous attack of enteric may give the hint when dealing with some obscure case of chronic cholycystitis. Similarly some chronic and intractable cases of cystitis may result from the persistence of the typhoid bacillus.

There are also certain large spaces within the abdomen filled up by cellular tissue which are favourite sites for abscess formation sometimes arising after enteric fever. Especially we may remember the cave of Retzius in front of the bladder, the subdiaphragmatic space, the retroperitoneal tissue, and the perinephritic tissues. Here again in some obscure abdominal condition due to deep-seated abscess-formation the history of a previous attack of continued fever suggesting enteric may give the clue.

As regards questions of treatment in enteric raised by Dr. Davidson's paper, it seems to me that the great danger we have to avoid if possible in European patients in this country is that due to fermentative processes going on within the bowel producing a liability to abdominal distention. To prevent this I invariably use the formula given by Burney Yeo for a solution of chlorine with quinine, and certainly it always has the effect which Dr. Yeo claims for it. The tongue cleans and the stools lose all smell except perhaps that of the chlorine itself, and moreover the temperature tends to fall. My practice is to write out full directions to the chemist for its manufacture from strong hydrochloric acid and powdered potassium chlorate, so that the solution is obtained fresh as required. This does prevent a tendency to distension of the small bowel and thereby reduces the danger of perforation.

Dr. S. A. Battliwala said:—I am completely in accord with Captain Gordon Tucker as regards the use of Chlorinated Quinine Mixture according to the formula of Professor Burney Yeo. It is really a mixture, which if used from the very beginning of the fever, serves not only to control many complications which generally accompany Enteric Fever, but it reduces the duration of fever from three to two weeks or even less. This result I have noted in my practice where the cases were confirmed as of Enteric Fever by Diazo Reaction or the sixth day of the fever and positive Widal's test on the 10th day of the fever.

The mixture works satisfactorily on Indian and European patients alike. But what I want to expressly mention to you to-day is a drug which acts very successfully on the Distention of the abdomen and Diarrhœa. I mean the use of the Cyanide of Mercury in 1/20 grain dose three or four times in a day according to the urgency of the case. This drug has been known to act very well in Cholera as has been proved by trials taken by Khan Bahadur Dr. Choksey at the Arthur Road Hospital and which was mentioned by him in his paper on Cholera before this Congress. I have noticed that immediately on the slightest tendency to Diarrhœa occurring in the second week of the disease, or on any distention of the abdomen being noticed, on any undigested milk passing in the motion, or any foul smell being detected, not to speak of the characteristic Pea-soup stools, the Cyanide of mercury pushed once, twice or thrice a day in the dose mentioned above goes a great way to control the Diarrhœa and Distention. It alters the character of the motions, changes their colour, removes foul smell and controls their frequency. You will therefore see that it acts indirectly as a great safeguard against Hæmorrhage.

HILL DIARRHŒA.

By A. G. NEWELL, M.D., C.M., L.M., D.P.H., Kurseong.

The great doubt as to the ætiology of hill diarrhœa and the proper method of treatment incite me to make a few remarks on this troublesome complaint which is generally regarded as having an obscure pathology. With some experience of the disease and ordinary observation I came to the conclusion six years ago that hill diarrhœa is due in the first place to the diminution of atmospheric pressure causing a deprivation of the blood from the internal organs, and as the blood of most subjects of this disease is none too much in quantity nor of too excellent a quality, there is necessarily a diminution of the functional activity of the organs so deprived of blood. Consequently if the liver and bowels are deprived of some of their blood owing to the sudden rush of more blood to the surface of the body it is not surprising that the secretory activity of such organs will suffer, and if the diminution of atmospheric pressure is accompanied by a marked diminution in the temperature of the atmosphere,—as happens in India where people from the plains rush to the cooler hills, —it is only to be expected that such organs will fall an easy prey to the action of chills. Therefore the *sudden* difference in altitude demands a greater care against the exciting cause—a chill; the former being regarded as the predisposing cause as well. A man, coming from the plains of India, with a watery blood of diminished and enfeebled blood corpuscles, to the heights of Darjeeling will deprive his internal organs of a certain quantity of blood as a result of the diminished atmospheric pressure, and these will become liable to chill if not properly covered by *sufficient* garments of *a suitable* nature to keep them warm lessening the depletion and counteracting against chill. This is all the more necessary when one considers that however sufficiently clothed a certain amount of depletion of internal organs is bound to occur by a greater supply of blood to the lungs and to the exposed parts of the body. Note the greater difficulty of getting one's breath on first arrival on higher altitudes and the early acquirement of rosy cheeks as evidences of the action of diminished atmospheric pressure. With body *sufficiently* protected there is lessened the danger of chill, and time is given for the body to make up new corpuscles and sufficient blood for the altered environment. I have not seen anywhere this view of the causation of hill diarrhœa and I think this atmospheric theory of mine is the probable one—chill being only the exciting cause under the altered environment so caused, and possibly in some cases chill may be absent, though I should think rarely. Chill itself will not cause it as chill of these organs may be encountered in the plains but with no hill diarrhœa as we know it. My experience of the disease during six years has only tended to confirm these views. The organs affected are the liver and gastrointestinal tracts. There is a diminished activity of them leading to lessened and defective secretions whereby gastrointestinal digestion is interfered with, and intestinal floræ, which under normal conditions are kept in hand, grow luxuriantly and aid the alteration of undigested debris with putrefaction. People born in the hills, as the natives of the place, do not usually get it, being immune from birth more or less. A native hill-child is usually brought up with very little clothing on, and this, with hereditary immunity, protects them from chills. But I have seen hill diarrhœa in the rains both among children and adults among natives. These have occurred from exposure to rain and living in wet clothes, but even in these cases recovery is speedy. As regards the *mica* theory, I cannot but regard that as a pure myth. There is no proof of it. Even Europeans are constantly taking mica in their water and there is no general tendency to hill diarrhœa among them. Furthermore, if mica did cause the disease we should find hill diarrhœa cases distributed throughout the year, and European residents would be as liable to it as strangers. On the other hand the disease is more prevalent during the rains when a chill is more easily engendered, especially during the " breaks " in the rains, and strangers are more liable than residents. Residents are also probably less liable as they have become accustomed to the alteration in atmospheric pressure, and their bodies are supplied by the necessary quantity of blood, and also because they have become accustomed to suitable clothing annihilating the tendency to chill. With regard to the *particles* of mica in water, when one considers how very fine they are, it is more probable that these particles will get mixed up with the fœcal matter, and thus lose their possible physical qualities to harm when ingested, than to imagine that they should specially escape the fœcal mass and lodge themselves in the follicles of the intestine ! I am not aware that mica particles have ever been found so lodged *post-mortem*. Even the finding of such particles would not explain the very evident alteration in the colour of the stools as due to deficient bile secretion, and which deficient bile secretion explains the offensive character of the stools. No one surely would say that such insoluble matter as mica was absorbed and affected the bile secretion ! Again the lodgment of mica particles in the follicles would lead to pain, irritation and blood whereas the diarrhœa of " Hill diarrhœa " is frequently painless, is bloodless and white. It is the frequency of the stools from containing undigested fermented debris that gives rise to the local pain or tenesmus, but anything like severe griping pain is usually absent. Its greater prevalence among strangers and among males supports my theory. The greater prevalence among males is explained by the fact that they are more exposed, their livers are probably more deranged from alcohol, sedentary habits in offices, and additional chances of exposure during late hours of return to their houses. As regards children, invariably, it seems to me, to be a case of deficient clothing or a chill resulting from neglect probably throrgh ayahs permitting the child to sit in wet or damp places or getting soaked. The question of *sufficiency* of clothing is an all important one and probably one with a great relationship to the

individual case, and also one upon which many different views can be obtained as to what is "*sufficiency*." A man, for example, may consider he is sufficiently clothed for a change to the hills by a thicker pair of trousers, a thicker coat and a thicker waistcoat in place of the white cotton ones used on the plains. In probably few cases will this be *sufficient* and unless there is a non-conductable material next to the skin chill is liable to act. In the case of children the degree of extra clothing required is, probably, relatively greater. A child probably can't be clothed too carefully nor too much (taken in reason). In bringing up my child from the plains when first coming up with him I thought I had him sufficiently protected to a sufficient degree by extra clothing which most people would have considered *sufficient*. He had no water of the district (another case against the mica theory) to drink—only milk, yet he soon developed the early symptoms of hill diarrhœa. I at once put on a flannel bandage over the whole breath of the abdomen and gave him, then, Hydrarg creta, Benzonapthol and Bismuth Salicylate. He was almost immediately himself again and the binder was maintained, and when he later took the water of the district did not get the disease. Later on again there was a tendency to recurrence of the disease when the binder was somehow removed, but on the binder being reinstated he has kept free of the disease. Since then (6 years ago) to now he has kept free but having a non-conductable material next the skin. The degree of extra clothing therefore is of vast importance which can be supported by other cases. With reference to medicinal remedies I believe none are required beyond a preliminary hepatic cholagogue *if the case* is got *early* and *sufficient* clothing put on. The combination of an intestinal antiseptic is not absolutely necessary though of course it will aid the antiseptic action of the bile outflow. An antiseptic alone will not relieve the condition, and it is very improbable that any antiseptic could be given in sufficient quantity to retard the action of the intestinal floræ. The giving of astringents pure and simple should be condemned. I have found of great value, and I regard it as a specific, a combination of Liquor Hydrarg Perchlor, Acid Hydrochlor dil, Ac. sulph. dil, Vin Pepsinæ, with Chloroform water. This formula of mine, varying the dose according to age, has cured over thirty cases, and in no case have I ever ordered the affected down to the plains. I have known such a course make the patient temporarily worse. The good results of the Liquor Hydrarg Perchlor in such cases is probably due to the Cholagogue effect. The antiseptic effect of the solution is probably doubtful owing to decomposition of it. The Hydrochloric Acid and the Vin Pepsinæ aid the digestion of the nutriment given which should always be small in quantity and frequently repeated. The mixture should be given three or four times a day. The Ac. sulph. dil. helps to check peristalsis. In late cases which have been sent to sea the beneficial effects are probably due to the departure from the influence of the atmospheric pressure and the possibilities of chill. Probably many of these cases would have been cured by altered conditions of clothing and mode of life after having a dose or so of the mixture referred to. Sprue I regard as having nothing to do with hill diarrhœa, but as being connected with a germ probably allied in action to that causing Beri Beri (at present unknown). The disappearance of the mucus membrane and muscular coat of the bowel in aggravated cases of sprue (as I have seen *post-mortem*) point to a poison acting on the nerve supply of these parts. That a case of hill diarrhœa badly treated and allowed to continue too long may lessen the vitality of the intestinal wall and thus allow it to become the prey to the cause of sprue is however possible, but in no other way am I able to convince myself at present should hill diarrhœa ever degenerate into sprue.

With regard to diet, as there is deficient secretory activity and a catarrhal condition present, it is wrong to put either too much food or food of an irritating nature into the digestive tract. Therefore excess of proteid is inadvisable and the form of proteid should be in small finely divided particles in order to lessen irritation, and at the same time render it easier of action by such secretion as there may be. The same remarks applied to carbohydrates. Hill-diarrhœa may pathologically be regarded as a catarrh of the chylopoetic viscera induced in the manner described and its treatment consists in treating the condition generally on scientific lines.

A DISEASE RESEMBLING TYPHOID FEVER, IN DELI, SUMATRA.

"PSEUDO-TYPHOID FEVER."

By Dr. W. SCHUFFNER and Dr. MARGARETHA WACHSMUTH,

Director and Assistant of the Senembath-Tobacco-Society Hospital, Deli, Sumatra.

The diagnosis of typhoid fever becomes always more a bacteriological one. This is true for Europe, still more in the tropics, where a great number of "unclassed" fevers complicate the diagnosis.

Since many years we found in Deli not only *typhoid* and *paratyphoid* fevers, but also fevers, where the clinical and post-mortem examination gave a negative result qua typhoid and paratyphoid bacilli. Since 1½ years we have studied all fever cases by modern bacteriological methods intending to separate the "true" typhoid (and paratyphoid) fever from other diseases. In this way we have studied 300 cases, and made 1,100 cultures of the blood and a larger number of agglutination tests.

For the agglutination we use the method Neisser-Proscher (formaline suspension of typhoid and paratyphoid bacilli, cultivated in Sumatra) the lower limit of

the agglutination titre being fixed at 1·100. In each case the agglutination test was repeated 3—8 times, if necessary; cultivation of the blood was also made 2—5 times, always with agar and bile agar.

In this way the authors collected a great many "true" typhoid cases as some selected temperature charts will show.

In addition to these "true" typhoid cases, with bacilli in the blood or high agglutination test, there were always many cases of fever, without any positive result. The question is now, are these also *true typhoid fever cases or not?*

It is not possible to decide in a *casuistic* way, many cases of true typhoid fever have been observed without bacilli in the blood and without agglutination power of the serum.

At this moment we dispose of an *epidimiological* argument for the hypothesis that there is a disease, with great resemblance to true typhoid fever, but which has nothing to do with one of the bacilli belonging to the typhoid-paratyphoid group.

In the estate Goenong-Rinteh, one of the seven Senembah-estates, which send their patients to the central hospital of the authors, they observed a striking accumulation of fever cases, with no bacilli in the blood and negative agglutination test; and at the same time in all the seven estates a falling off of "true" typhoid, (as is shown in the diagram of the fever cases of Goenong-Rinteh).

The supposition must be rejected that all these fever cases from this one estate should have been mild (rudimentary) cases of "true" typhoid; first by the fact of the accumulation in one place; and secondly by the fact that there were several severe cases among them.

The peculiarities of this disease, which the authors call for the present "pseudo-typhoid fever," will be published elsewhere *in extenso.*

At the Congress the temperature charts and other clinical details of a large number of pseudo-typhoid patients are demonstrated; you will find indicated on them all about:—

Temperature.—(Several cases with relapses, resembling typhoid).

Pulse.—(Rather frequent).

Respiration.—(Seldom bronchitis).

Urine.—(Generally albuminuria, never nephritis).

Intestine.—(Never hæmorrhage or perforation, usually constipation).

Ears.—(Now and then deafness, in 2 cases otitis media).

Lymphatic glands.—(Very often swollen and painful, especially in the neck and throat).

Blood.—(Nearly always hyperleucocytosis, decrease of the amount of hæmoglobine: cultures and agglutination negative).

Spleen.—(Swollen).

Skin.—(In a quarter of the cases a slight, often nearly invisible or measles-like exanthem is observed, now and then even hæmorrhagic. In severe cases, however, this symptom was often absent).

There are fatal, severe and mild cases, a fact which is characteristic for an infectious disease; many cases have only been recognised in an epidemiological way.

The beginning of the disease seems to occur suddenly, the patient feels himself very ill and complains of fever.

When the disease ends fatally, many days of soporous condition precede death. During the decrease of the fever the patients do not recover so rapidly as "true typhoid" patients generally do; they remain somnolent for a long time although their temperature may be normal.

ÆTIOLOGY.

The negative results of cultures from blood, fæces, urine, lymphatic glands, etc., and, in the two fatal cases, also from liver, spleen and bile, and the negative result of the microscopical examination seem to exclude a bacillus of the typhoid-paratyphoid group as the cause of the pseudo-typhoid fever.

There is reason for suspecting an ætiological factor, resembling the cause of malaria.

Coolies (from different nations) *working at the same spot*, were the only victims of the disease; they were living, eating and drinking in 5 groups in different houses. *Their work only connected the men.*

The different groups were living in houses and eating and drinking with coolies, who worked elsewhere, none of these other men contracted the disease. When people from another estate (Patoembah) came for help to the infected estate several of these men got the disease.

Infections in the hospital have not been observed.

Ticks do not seem to be the cause; the symptoms of tick biting, as described by Tanaka, were not present.

The "pseudo-typhoid fever" is different from the River fever by the high mortality and the symptoms of the lymphatic system (local bubo) of the latter. From typhus (examthematicus) by the kind of contagion.

Dengue fever is also a very contagious disease, and very different from the above described "pseudo-typhoid" fever.

NOTES ON TROPICAL DIARRHŒAS.

By FREDERICK S. MACY,

First Lieutenant, Medical Corps, United States Army.

In the consideration of this great subject we are confronted with a state of chaos. Our knowledge of these affections is in its infancy, and what we do know is unclassified. It must not be forgotten that diarrhœa is a symptom, not a disease entity. Yet it is so often the only manifestations of some disorder that it overshadows in clinical importance the primary trouble of which it is an evidence. Therefore it is justifiable to reverse the true scientific order by considering the manifold causal conditions in reference to this cardinal attribute, ascribing

to it, rather than the underlying disease, the chief place, in order to facilitate study and classification.

We may find it convenient to group these cases provisionally as follows:—

1. Diarrhœas due to causes exclusively within the gastro-intestinal tract.
   (*a*) Benign, or non-specific in origin.
   (*b*) Malignant, or specific in origin.
      1. Those due to vegetable parasites.
      2. Those due to animal parasites.
2. Diarrhœas due to causes outside the gastro-intestinal tract.

These include cases resulting from disturbances in other organs, from toxins elaborated elsewhere in the body, solar, climatic and thermic influences, parasites such as the schistosomes, malaria organisms, and the rarer flukes; nervous disturbances, hepatic derangements, abscess, cancer of other parts, etc. Those due to cardiac and renal diseases are not of peculiar interest to tropical medicine.

The term "diarrhœa," is commonly limited in meaning to describe those abnormal intestinal discharges characterized by fluidity and frequency. It may, however, be extended in meaning to include those cases in which the dejecta are voided more often than is normal, regardless of the consistency of the fæces, which may be solid. The latter condition, many formed evacuations, is far less common than the former, though it is occasionally encountered. As benign tumors are sometimes fatal, so also are the non-specific diarrhœas. And as malignant growths do not necessarily always end in death, so may the specific diarrhœas terminate similarly in recovery.

In the benign or non-specific diarrhœas the dejecta are practically always liquid and numerous. They do not differ essentially from similar attacks outside the tropics, and are all characterised by relative shortness of duration, and ready response to appropriate treatment. If the cause be removed there is no permanent anatomic, functional or constitutional change. To this division belongs the ordinary acute catarrhal enteritis, due to the ingestion of improper or unaccustomed food; such as unripe fruit on the one hand, and fresh meat after a long period of deprivation on the other. Or the attack may be provoked by some mechanical irritant, such as dust swallowed in unusual amounts during a march, or inorganic matter introduced with the drinking water. Often these attacks are not strictly catarrhal in nature, but are induced more especially by increased peristalsis as a result of the irritation produced by the foreign substance. The discharge, under these circumstances, is watery or serous, rather than catarrhal or mucous.

Any portion of the digestive tract may be affected, from the stomach and duodenum to the rectum; but inasmuch as the entire canal is more or less involved, it is seldom possible to differentiate the part chiefly concerned: nor, for the matter of that, is it of prime importance to do so, in many cases, so far as treatment goes.

But the next class, the specific diarrhœas, deserve more careful attention. They are more strictly tropical in distribution, are always attended by more or less permanent anatomic and constitutional changes, and tend to become chronic in spite of treatment. They are, as a group, always due to parasites of some kind, either animal or vegetable.

And right here we are forced to admit that we know comparatively little about either variety of infection. The field is becoming larger each day, our knowledge is increasing, and we are on the eve of undreamed things. But at present we see too often some strong man brought low and invalided for the rest of his life, and the only explanation we can offer is that he had diarrhœa. No amœbæ of any kind were ever found, nor any other sort of parasite. His blood did not agglutinate Shiga's bacillus. In short no specific cause was ever discovered. He was given everything from bismuth to ipecac. He was lavaged with this and with that, and finally he was sent home, a human derelict. It is a common picture, common to all alien races whose destiny compels them to inhabit the tropics. It is for us to recognize causes, and to ascertain means to destroy them.

In the first place, the fact has apparently been overlooked that the *bacillus dysenteriae* is not the only kind of vegetable parasite that is capable of producing diarrhœa even of a fatal sort, that is found in the human intestine. There are over twenty others that are potentially pathogenic. Under predisposing conditions many of the ordinary putrefactive bacteria may excite violent symptoms: such as the proteus group; certain micrococci; some of which have received names and some not; and others resembling the subtilis group. Besides these, there must be considered the *bacillus enteritidis*, the *bacillus lactis aerogenes*, the *bacillus mucosus capsulatus*, the ray fungus, and others. Given a case in which the presence of animal parasites and the so-called bacilli of dysentery can be excluded, we are scientifically not justified in resigning to the unknown until a biologic test has been made with every organism that can possibly be a cause.

Not the least among the diseases of obscure origin is sprue. No organism yet isolated can be identified with the disorder, and we can only theorize as to whether the etiologic factor is bacterial or animal. That it is infectious there is little room to doubt, since it persists in patients who long ago were removed from the predisposing influences of the tropics; such as debility, malarial and other fevers, heat, in short the many depressing conditions incident to a sojourn in warm countries, and after all the apparent effects of foreign climate and surroundings have been corrected. Further, the main features of the disease are practically constant, varying in degree more than in kind; and this in itself argues a constant cause, though, it must be admitted, not necessarily a specific one. A very suggestive fact, if not a convincing one, is the experience of a nurse under my observation, who contracted the disease while on duty in a hospital situated in a locality where sprue is unknown. He could have acquired the infection only by caring for chronic cases which had been sent to the institution from places where it was prevalent. He himself had been stationed at this sanatarium more than a year and had never been exposed to any tropical

influences nor to the infection itself, except at the hospital mentioned.

It may be proper at this point to note certain findings which seem to me significant. If a very thin, even smear of sprue fæces be made, and stained when dry with one of the ordinary stains, as an alkaline, watery solution of methylene blue, there will be seen an exceedingly tenuous and faintly blue spirillum which differs from those common to other and normal fæces in size, shape and staining reaction. This organism is more closely coiled, often barely visible even in the dyed spread, is much more slender and will not grow on any media which I have yet used. It is present in great numbers, especially in the small, white, mucous threads that abound in some specimens, and is quite variable in length but not in breadth. In shape it is spiral, and the longer forms are sometimes bent so as to resemble three sides of a rectangle. Certain of them appear to have divided transversely, the apparently new cell so formed lying invariably at an obtuse angle to the parent cell. They are not distinguishable in unstained fæces, and since they have not been cultivated, it is impossible to describe any motility they may possess. They have been constantly and certainly found abundantly in every case of sprue which I have examined since I first noticed them, and so far I have never observed them in any other fæces, either normal or from other diseases. Cases admitted with a diagnosis of chronic diarrhœa, or some form of enteritis, have occasionally shown them, but careful examination of their histories as given by themselves and as furnished by previous attendants has, with one exception, revealed the occurrence of sprue in the past, while others showed symptoms of the disease at the time of the examination. The single exception cited is a doubtful case. While he gives some evidence of sprue at the present time, it is not so positive as to preclude all doubt.

As I have only recently noticed the presence of this organism, I shall have to defer a more detailed description of it and an opinion of its etiologic importance until another time.

There is still another class of vegetable organism which is unquestionably an etiologic factor in many cases of chronic tropical diarrhœa, as well as certain acute cases. I refer to yeasts, and coincidently to moulds. There seems to be no literature on the subject of a comprehensive nature and what there is is limited chiefly to a description of the varieties that are most frequent contaminations in the laboratory. Blastomycosis is being described but not of the intestine. As to the moulds, they, too, have received no consideration in works on intestinal diseases, except the occasionally encountered comment that the aspergillus may cause fatal symptoms. A brief reference is sometimes made to the oidium lactis. Yeasts and moulds in other conditions than intestinal are often described. But no importance has apparently been attached to their presence in the digestive tract. Yet a careful examination of the fæces will demonstrate in many cases fungi of this sort which are constantly present in the same patient. Their spores can be unmistakably dentified in the fæces, sometimes scattered here and there, sometimes in masses. It is less common to find mycelia. Not every one of these is pathogenic, of course ; and we can find them in normal fæces to an almost equal extent. For instance, the penicillium glaucum is present in every case in the hospital under my charge, and in 82 per cent. of the normal specimens examined by me. It would be folly to assign any pathologic significance to it in these instances, under the circumstances. But in one case I isolated a penicillium which grew best at body temperature and but slightly at room temperature. The patient with chronic diarrhœa from whom I obtained it may not have been diseased with this mould, but the point demonstrated was that some common and innocuous fungus may assume unusual features at times and under conditions now unknown to us; and when so altered in nature there is a possibility that it is harmful. I mention this only to suggest that we investigate this subject more fully and with more attention than it has hitherto received. Again I have four yeasts which I have isolated constantly in the patients so infected, 75 per cent. of whom have gastro-enteritis of undetermined causation, and all of whom are profoundly neurasthenic. This fact suggests the possibility that certain yeasts may elaborate substances which have a special affinity for the nervous system resulting in derangement of function or even in structural changes. Incidentally one yeast is from a sprue patient, but all such cases do not exhibit it. I have not as yet established any causal relationship to an intestinal disorder, in any instance, at least to my own satisfaction ; but the possibilities suggested by such findings deserve mention. We must bear in mind, however, that baking does not entirely sterilize bread or toast, and we must, therefore, compare yeasts isolated from patients with those in all articles of food given them which are likely to contain these organisms.

Although I cannot at present give any further results of investigation in this matter of yeasts and moulds as factors in producing diarrhœas, yet I shall soon be able to quote the results of animal experimentation with at least a few varieties, all obtained from diarrhœas of obscure origin and chronic duration. This applies also to certain bacteria in similar conditions.

Probably the most interesting etiologic factors are the animal parasites. Of these there are so many that a detailed description of the diseases in which they occur is not possible in a brief paper. Those found within the intestine are chiefly the following :—

- The entameba histolytica of Schaudinn.
- The ankylostoma.
- The amphistomum Watsoni.
- The gastrodiscus hominis.
- The fasciolopsis buski.
- The cestodes.
  - Taenia africana.
  - ,, saginata.
  - ,, solium.
  - ,, nana.
  - ,, hominis.
  - Dibothriocephalus latus.

The balantidia.
Œsophagostomum Brumpti.

Among the parasites outside the intestine which may cause intestinal fluxes, either as a secondary result of their presence in other organs or by being brought to the intestinal wall by the blood or lymph channels, with resulting local lesions, the most notable are these—

The schistosomum japonicum.
The schistosomum hæmatobium.
The Leishman-Donovan body.
Malaria parasites.
Tænia echinococcus.

Of course none of these invariably produces diarrhœa or dysentery, but all do when the conditions of growth are favourable, or they are present in large numbers. Nor is the list complete. It omits certain rarer varieties, such as the liver flukes. Neither does it include varieties which, so far as we know, never cause disease, such as the *tricocephalus hominis*. To the first portion of the list, however, I would add the *cercomonas intestinalis*, which is really the *cercomonas vaginalis* of Devaine, the *trichomonas* so generally confused with it, and the so-called *strongyloides intestinalis*.

I am aware that these parasites are ordinarily considered harmless, even though they may be present in chronic diarrhœa; but I nevertheless believe that such is not the case. That they are not always pathogenic does not mean that they never are, any more than the fact that a man may harbour amœbæ without showing symptoms means that this parasite does not cause the deadliest of dysenteries. I could cite several instances in support of this view, but a few in particular must suffice at this time. There was recently in my wards a certain patient with cronic diarrhœa, recurring at intervals over a period of about nine months. The dejecta were often bloody and always mucous, with a variable amount of solid material, and numbered sometimes as many as sixteen in twenty-four hours. There was tenesmus, and he suffered the usual exhaustion and debility accompanying his condition. No cause could be assigned. The fæces contained swarms of the *cercomonas hominis*, and the blood showed a relative increase in the number of mononuclear cells, with secondary anemia. The change in the blood count, involving the mononuclears, is alone suggestive of protozoan infection. Later he was so fortunate as to become free from the parasites. The diarrhœa soon ceased, though no treatment had previously availed, the blood became normal, and he is now, about three months later, apparently well. A similar case infected with the *trichomonas*, still under treatment, showed at first the alarming increase of mononuclears to 43·3 per cent., the ratio representing the proportion in a count of 1,800 white cells. During the past week the parasites have disappeared, his intestinal symptoms are rapidly diminishing in severity, and the count just made, four days after the first negative examination, shows a diminution of the mononuclears to 27·2 per cent. Several cases of chronic diarrhœa in which no other cause than the so-called *strongyloides intestinalis* could be found, could also be quoted. In some of these there was a very slight eosinophilia, never going above 8 per cent., and one who finally exhibited no trace of the worm recovered completely, after a more or less constant illness of about a year.

Given the absence of other causes, so far as could be ascertained, with blood changes characteristic of the species of parasite, and the subsidence of all symptoms after the disappearance of the creatures, I believe it is permissible to affirm that in these instances, at least, the parasites mentioned were the specific causes of the difficulty, and that it is proper to include them in the list of pathogenic organisms. Like the yeasts and moulds, it may be profitable to study the flagellata especially more carefully.

The principal extra intestinal causes of tropical diarrhœas have already been enumerated. We can readily understand the part played by a tropical liver, or by cardiac and renal affections; but it is not so easy to define why a sudden change in temperature, for instance, actinic and heat rays, or a derangement of the nervous system, should result in an intestinal discharge. Perhaps in many cases more material causes could be found upon closer examination. There is no doubt, however, that these are recognized factors. It may be that such diarrhœas are compensatory to a certain extent, and serve to assist in the elimination of abnormal products of metabolism, which has been perverted by these agencies. At other times, as when the patient has been exposed to some sudden fall in temperature, they may be natural means of relieving vascular congestion. Sometimes, too, intestinal fluxes are excited by the presence of toxins formed elsewhere in the body, and are useful, to a certain degree, in restoring the patient to his normal status.

The parasites mentioned as having their habitat outside the intestine, operate in different ways. In schistosome infections the passage of the ova through the intestinal wall produces so much irritation and even extensive tissue changes that intestinal symptoms are inevitable. The Leishman-Donovan body is brought to the intestinal wall through circulatory agencies, probably, and there gives rise to ulcerative processes. Malaria organisms are sometimes massed in the capillaries of the canal structure, with a more or less hemorrhagic dysentery as a result. Or they may produce a definite toxæmia, an excessive destruction of the erythrocytes, or both, without these accumulations, but with similar consequences.

The relative frequency with which different varieties of animal infection occurs varies in the several countries in which the subject is studied. In the Phillipines patients are sent to the sanitarium of which the writer is in charge from all parts of the Archipelago. Figures covering the year just ended are as follows :—

Amœba histolytica ...	... 37·5	per cent.
Amœba coli	... 35·0	„
Cercomonas	... 7·5	„
Trichomonas	... 2·5	„
Strongyloides intestinalis	... 12·5	„
Ascarides	... 2·5	„
Tricocephalus dis. ...	... 17·5	„
Ankylostoma	... 17·5	„

These cases were all examined without regard to diagnosis, and include findings in both normal and diseased fæces. Many harboured more than one kind thus:

Per cent. with	one parasite	30·0
,, ,,	two parasites	22·2
,, ,,	three ,,	10·5
,, ,,	four ,,	5·0
,, ,,	no ,,	30·0

Of those in whom no parasites could be demonstrated, even after repeated examinations, 25·0 per cent. had a history of amœbic dysentery, while approximately 12·0 per cent. of all the patients had a more or less positive history of sprue, or had been admitted for it.

It is pertinent to state that the representative value of these figures may be affected by the fact that most of the cases were intestinal; and admitted, in many instances, for diseases known to have been provoked by the infecting parasites. Hence the percentages are probably larger than would be the case had an equal number of healthy fæces been included. They are, however, very nearly indicative of the percentages in diarrhœal conditions in this part of the world. No other varieties than those named were present in any case, though more are encountered in these islands as in other tropical countries. Malaria parasites are not included in the second table.

It is hardly necessary to say that before treatment is prescribed or a complete diagnosis is made, the fæces should be rigidly examined. It is not so generally a matter of routine, however, to examine the blood. Nevertheless, this should not be omitted. The method followed by us at Camp John Hay, "the Simla of the Phillipines," is this. The second evacuation after the administration of a saline purge, as well as the first, is sent to the laboratory. It is not uncommon to find much useful information in the second stool that is not brought down in the first. While still warm, the specimen is examined for ova under the low power of the microscope, and every field in the preparation rigidly searched. In spite of the oft-repeated statement that the ova of uncinaria, of ascarides and of other parasites are present in great numbers in such infections and usually in almost every field, it is not unusual to find only one ovum in an entire spread, or even only after several slides have been examined. The search for amœbæ, yeasts, moulds, or other minute abnormal organisms, or the study of details, is then conducted with the higher powers. During these procedures, a gross estimate of the digestive activities and deficiencies can be made from the debris, crystals, fibres, etc., observed. It is not amiss also to ascertain the reaction of the dejecta.

Not only one but several slides should be prepared from the same specimen, even though the findings in the first are sufficient to account for the symptoms. All the abnormalities may not be demonstrable in the one slide, and what is found last may be the most important of all. Careful notes are made of all the findings, with remarks on any unusual morphological phenomena that may be seen, especially in the case of amœbæ, so much discussed at present. The specimen is now carefully covered and put away at room temperature. This is because larval forms or flagellata occasionally develop in the course of twenty-four hours, of which the material showed no sign at first. It is necessary, of course, to rule out accidental contamination in such an event. I remember one instance in particular. There were no parasites of any kind at first discovered, but there were great numbers of small, spherical, refractile bodies which stained faintly pink by Wright's modification of the Romanowski stain, exhibiting a thin outer wall and an apparently homogeneous interior. At the end of twenty-four hours there were swarms of very active flagellata, and these answered the description of the cercomonides. The small bodies mentioned were still present, but many appeared broken or split. Some appeared larger than any seen the day before. The parasites themselves were of variable morphology. There was one type, reniform in shape, blue in colour, containing a red spot, probably of chromatin, and at one end was seen a round, reddish purple spot or body exhibiting a plane above and below that of the animal, much like one of the spheres mentioned before. No flagellum was demonstrated. This was the only type in which the general details were distinguishable in unstained preparations. In the latter it appeared as a slow moving body, progressing with an undulatory motion, and possessing at one end a very refractile, circular area. Another form was small and round, pale blue in colour, and at one place, usually eccentrically, there was a transparent portion which contained a few red granules, rod-like in shape. In larger individuals of this kind there was occasionally faintly perceived what appeared to be a flagellum in contact with the capsule, looking like a faintly purple line. In another type, slightly larger in size than any of the foregoing, and staining like the last, a flagellum could be seen extending from one pole of the organism as a purple, wavy line, which took the stain very slightly. In the largest specimens the protoplasm stained purple instead of blue, no flagellum could be seen, and red spots were diffused throughout it here and there. And finally, some were seen in which there were from eight to fifteen purple-red circular spots located in the protoplasm, exactly like the small bodies first noticed. Some of these bodies showed only vacuoles, stained very poorly, and were apparently dead. A great many slides were stained before these types were successfully seen, and a great many smears had to be made in order to furnish material enough to cover the several weeks consumed in examining them. I mention this as a matter of precaution to those who may see similar forms and wish to study them. They are very suggestive of sporulation.

So, then, it is evident not only that we should keep our specimens for a day or more, and then examine them again, but that it is not unwise to stain very thin, even smears of the material, as well. Yeasts and certain mycelia are especially visible in such preparations. I have already described the pale, slender spirillum seen in sprue fæces, and it may be well to ascertain definitely whether or not it ever occurs in any other conditions.

Not only should several smears of the same fæces be examined, but specimens should be obtained at frequent intervals, as for example when the patient complains of a

new symptom, or one which he has not hitherto exhibited; when he is worse, and on the other hand, when he says he is better.

If it is desired to study any fungi that may be present or suspected, it is well to sow a loopful of the fæces in sterile bread paste. For a time the bacteria, or certain of them, will develop, as well as the other fungi; but they are so overgrown by the latter that a series of plates of saccharine media made at the end of a week or more will show colonies of yeasts and moulds, if present, almost exclusively.

Separate plates should be made to isolate the bacteria, and the media selected should all be plated in long series if it is desired to make the isolation comprehensive. Even then there will remain some organisms which cannot be recovered.

Finally, both the solid and the fluid portions of the specimen should be examined separately. Ova are most numerous in the formed material; larvæ flagellata and amœbæ in the liquid or mucous part. These examinations can often be advantageously supplemented by a chemical one.

I have emphasized the importance of examining the blood in all cases of tropical diarrhœa. The examination should include not only an estimate of the degree and a determination of the kind of any anæmia that may be present, but also a careful analysis of the white cell contents. Above all, a differential count, relative and absolute, should be made. In this way, basing the percentages upon a count of at least four hundred, valuable clues to obscure conditions can sometimes be obtained. If the mononuclears are increased we must consider the possibility of cancer somewhere in the tract, or even elsewhere, or which is more commonly the case, protozoan infection. If the eosinophiles are increased, especially to a high degree, we should unremittingly search for hook worms even though their ova have not been seen after many examinations. Leucocytosis, or an increase in the polymorphonuclears, warrants in either case, in amœbic infections, a suspicion of liver abscess and is an early warning. It must not be forgotten that a relative increase in the number of mononuclears may be only an apparent one, and result from a diminution in the number of polymorphonuclears. The latter are diminished in conditions of debility, especially that so prevalent in the tropics, and the other cells, which are not proportionately affected by this state, may seem to be increased in number, though normal or nearly so by absolute count.

Incidentally, malaria organisms, or evidences of them, may be discovered at this examination.

At the time the blood smear is made, a few drops of blood may be secured for making agglutinative tests with such bacteria as have shown the reaction in diarrhœas. If the serum be centrifugalized in a small tube, as in making opsonic tests, it is possible therewith to estimate to a quite reliable degree the gravity of the affection. A patient who has subsisted upon the ordinary food materials should yield a more or less turbid serum during the alkaline tide of digestion, and even longer. This appearance is due to lipæmia, and the absence of finely divided or emulsified fat in the serum a few hours after eating is indicative of grave interference with nutrition, and consequently indicates serious intestinal difficulty of some sort. The food selected for the patient should contain considerable fat, preferably in the form of cream or butter. The amount of fat recovered, as described by Neisser and Brauning, is the index sought.

The practical clinician will object that if he consumed the time necessary to conduct these examinations there would remain none in which to treat his patients. But the former should be done for him. Much of it is done now. Laboratories and similar institutions are very general; but each of these in the tropics should make a speciality of this kind of work, even to the maintenance of one or more specially detailed men, whose sole duty should be to establish cause and to evolve every feasible vaccine, serum, or other specific that would correspond. The importance of the subject justifies the specialty. Dysentery, especially the amœbic form, permanently injures or utterly destroys more human beings annually than any other disease, except tuberculosis, and more than plague, yellow fever and cholera combined. Indeed the latter may with propriety be included in the list of specific tropical diarrhœas. The ratio of admissions to military hospitals in time of peace for intestinal fluxes is approximately 75 per 1,000 of total strength, while for digestive diseases in general it is about 260 per 1,000.

So much of this sort of disorder prevails in warm countries especially, that a laboratory cannot always devote sufficient time to the due consideration of each case without encroaching upon the demands of other more general work. Yet the proper treatment of these diseases, to be specifically and accurately directed, must depend fundamentally upon a careful and minute analysis of the individual infections. It is useless to attempt the cure of a patient who is wasting away with ankylostomiasis, for instance, by palliating his occasional bloody diarrhœa with bismuth and opium; yet many examinations of both fæces and blood may be necessary before the real condition is discovered: a procedure which requires more time than the busy practitioner can afford. The patient should always have the benefit of special means and facilities, for the best is none too good for a sick man.

The principles applicable to all cases are chiefly the following:—

1. Removal of the cause, whether it be organic or inorganic. In the non-specific cases a purge should be given unless there is good reason to believe that the offending material has been removed by nature. An intestinal sedative or astringent should then suffice. In the specific cases the removing agent must be some special measure which is known to destroy the specific origin, in addition to the purge.

2. Minimizing the digestive labour. This is regulated by the diet, which should be selected with a view to assist in meeting the next indication, which is—

3. Improvement of the general or constitutional deficiencies, such as anæmia, exhaustion, neurasthenia, malarial cachexia, and faulty hepatic action, which are the defects most commonly encountered.

4. Checking of too profuse evacuations. Diarrhœas are so often an effort on the part of nature to remove deleterious chemicals or parasites, that we should be well satisfied with our knowledge of the case before we adopt too stringent measures. Yet nature sometimes acts not wisely but too well, and we should then attempt to govern, but not to control her. The mere fact that the bowels are too active is not the first consideration.

5. The relief of pain and other special symptoms, such as sleeplessness, tympanites, thirst, and craving for special kinds of food. These desires are not seldom an expression of the needs of nature and a guide to the kind of medication that will be most efficacious. The commonest request, perhaps, is for something acid, as pickles. Of course he cannot have pickles, but dilute sulphuric acid will sometimes satisfy him and relieve his symptoms. What he desires is not necessarily the particular article of food, but is sometimes a substance unknown to him, which is translated into terms of food, the distinguishing quality of which he instinctively recognizes as most nearly resembling that of the substance wanted by his system. While too much stress must not be laid upon these cravings, they should not be wholly ignored.

In principle, a single drug is better than a combination if it will meet as many indications. When a combination is given, it should consist of as few remedies as will answer the requirements, remembering the capabilities of a carefully selected diet, of massage, etc., and the individual peculiarities of the case. Probably more patients are hindered by over-drugging than by under-drugging.

On the other hand we are apt to under-feed our patients. The endeavor should be to give them the maximum of nourishment with the minimum of digestive labour; including in our calculations, to some extent, the portion of the bowel affected, as well as the degree of ulceration that may be present. In this connection I wish to emphasize the point that milk must be considered a solid food, and not as easily digested as was formerly supposed. Sometimes the ill effects attributed to over-eating in these diseases are the result of errors in selection, not in quantity.

The drugs chosen for the case must, of course, be selected with reference to the special action desired. Ipecac. does signal good in bacillary infections. It is not a specific, however, as some have claimed. In the Philippines we have seen much benefit derived from it in amœbic infections also. The first course of the drug seems to confer the maximum of benefit. Subsequent courses are of progressively less value. I have so rarely seen the disagreeable effects ascribed to the large doses directed that I believe this feature of the ipecac. treatment has been exaggerated.

A decoction of simaruba and pomegranite is a most unpleasant remedy, but a very efficient one. It sometimes effects an apparent cure when all else has failed. Lactic acid bacilli are valuable.

Rectal irrigations of very dilute sulphuric acid are sometimes successful in removing flagellata. As to the high flushings, I believe that they are of benefit in a small proportion of cases who can endure them. As a routine procedure they are to be condemned.

In chronic amœbic dysentery there is no treatment so valuable as appendicostomy. I think that the failures, such as sloughing of the appendix, which have been reported, are due largely to destruction of the blood-supply. If the meso-appendix is left intact and drawn up with the appendix so as not to rob the latter of its one small artery, success will be the rule. I have seen a gain of forty-five pounds, in about six weeks, result from irrigations through the appendix, in a case which had been bed-ridden for more than eight months. He made a splendid recovery, and others report equally favourably on the operation.

In regard to our neurasthenics with diarrhœa, we should remember that this condition is fully as often the result of the intestinal processes as the reverse. I have spoken of the possible connection between yeast invasions and nervous symptoms. In any case complicated with a nervous state, it is well to consider the possible influence of animal or vegetable parasites in the intestine. Much more can be explained at times in this way than is conveyed in a diagnosis of "nervous diarrhœa."

In concluding these short notes, I wish to apologise for the superficial character of this paper. I have left much unsaid for the reason that others will treat of the individual diseases, or the most important of them, in greater detail under their several titles than is possible in a paper of this scope. If only these general points may serve no other purpose than an introductory one, I shall be well content and grateful for the opportunity of presenting them to you.

THE MATERNAL DEATH-RATE IN BOMBAY.

By Lt.-Col. M. A. T. COLLIE, M.B., I.M.S.

I have had little time to collect and elaborate clinical material, and I must leave to others original research which can only be done in this country by those whose time is not occupied in administering large institutions and attending to the multifarious duties which such appointments entail. There are matters, however, which in the pursuit of one's profession often demand serious thought. I have selected the high mortality amongst mothers and infants as a subject to bring before you; the fact that such is the case is well known to all my colleagues here, but I hope, by presenting certain data, to accentuate the importance of the subject. Our means for preventing such high death-rates in this country are extremely limited from a professional point of view, but

if the measures which I shall suggest meet with approval of my colleagues then I think much lies in our power, by combination, to reduce a mortality which, throughout the Indian Empire, must be appalling. That this mortality is to a great extent preventible is shown by the experience gained in Europe during the last 50 years; Dr. Temuljee Nariman, of this city, can also show what incalculable benefits the Parsi community has gained from measures which he was instrumental in introducing. The difficulty in India of collecting data appears almost insuperable, but, as far as I know, we have in the returns prepared by the Executive Health Officer of this City (Dr. Turner) the most reliable information available in India at the present day,—even though they are admittedly defective owing to the ignorance and apathy of a public not yet educated to Western methods. I have therefore no hesitation in utilising for my purpose the information afforded in Dr. Turner's reports as I imagine they are not accessible to the majority of those present. In his report Dr. Turner takes the returns for the City of Glasgow as the most suitable for comparison with Bombay,—the population of these two cities being nearly similar; these statistics, as far as they relate to the subject before us, will be shown side by side.

Taking first the mortality from "puerperal fever" for the past nine years the Bombay Municipality returns show:—

	1900	1901	1902	1903	1904	1905	1906	1907	1908
Bombay...	860	514	576	365	364	359	532	384	360
Glasgow...	78	71	590	108	89	108	119	...	...

We may take it that these figures, as far as they relate to Bombay, only represent cases returned as such, but from our experience it may be assumed that they fall short of the actuals. Amongst the many measures introduced by Dr. Turner for the benefit of the people is that of providing Municipal District Nurses and they were first employed during the latter 6 months of 1907; from the returns supplied by them it appears that of the 11,785 cases of childbirth registered from July to December 1907, 5,412 came under the personal observation of these nurses. Of these 5,412, 13·7 per cent. were attended in hospital or by medical men, 79·8 per cent. were attended by native unskilled women, and 6·5 per cent. by qualified midwives. Dr. Turner shows that in Glasgow 26 per cent. were attended by medical men, 25 per cent. by qualified nurses, 44 per cent. were not attended by any qualified persons, and 5 per cent. unknown. Thus about twice as many were confined in Bombay "without skilled attendance" as compared with Glasgow.

As Consulting Medical Officer to the Oriental Life Assurance Company, I have been struck by the large number of deaths assigned to childbirth by applicants in giving their "family history." Through the courtesy of the manager I have had 3,500 proposals examined and find that in 750 of these (over 21 per cent.) the death of a mother or sister has occurred as a sequel to childbirth. In the great majority of these cases death is stated to have occurred within a week or 10 days, so that even allowing for the possibility of some disease not directly attributable to childbirth, you have a dreadful death-rate of women in their prime and a very large number of households thrown into mourning by a mortality which is largely preventible. The business of this Insurance Company extends all over India and it draws its clients largely from mofussil districts. If, with the facilities afforded in Bombay, only 20 per cent. of lying-in women have skilled attendance what must the case be in many other parts of India? I think it reasonable to assume that the portion of the public which is intelligent enough to insure their lives would also be intelligent enough to utilise skilled attendance in labour,—were it available.

We now come to the practical question, what measure should be adopted in order to prevent what I consider to be, to a large extent, a preventable mortality? The first and chief measure is that indicated in the heading of this paper—a more active policy in providing the women of India with skilled nursing. This is a subject which I have urged on several occasions officially and otherwise during my service, and I believe that progress in the direction I indicate is retarded by want of amalgamation and co-ordination. If we go back to the beginning of the nursing movement in this City we shall find that in our European hospital it was taken up by enthusiasts who, from their private means and by individual efforts, gave of their best but could only attend the most serious cases. Then the Sisters of the Community of All Saints, to whom this City owes so much, took up early in the 1880's the nursing of St. George's hospital, with the encouragement and financial assistance of the Hospital Endowment Fund and Government; under the Sisters' able management this hospital was the first to be efficiently nursed and from it the general public were soon provided with trained nurses. Then followed the Cama and more recently the hospitals attached to the Grant Medical College, but there are still hospitals in this progressive City which are inadequately nursed. The present policy of Government is to contribute towards the nursing of an institution a sum equal to that contributed by the general public, a liberal enough policy, where you have a liberal public. The weak points of the existing system are, first, that each individual institution becomes a separate organisation, and, secondly, that it is only in wealthy cities that such institutions can expect substantial support from the public. Nursing is, or should be, for the benefit of the people, as a whole, and I do not think it possible to extend its benefits throughout India until this system of watertight compartments is replaced by amalgamation, control and direction with a definite policy, and the recognition that no hospital, whether in wealthy cities or in poor mofussil districts, is adequately equipped unless it has its nursing staff. It must also be recognised that no nurse can be properly trained under at least 3 years in a large well organised hospital and that hospitals with 10 or even 30 beds cannot give certificates of training. Under present conditions no institution will employ a larger staff than its funds will permit and even at a liberal estimate the number of efficiently trained nurses which

can be turned out cannot for generations meet the urgent requirements of the people of this country.

A few years ago I ventured to submit a scheme to Government which is still under consideration. The main proposals in this scheme were:—(1) Formation of a nursing service on the lines of the Military Assistant Surgeon and Hospital Assistant Classes. (2) Contributions to be given to a central fund which should be administered by a Committee consiting of representatives of Government and delegates appointed by existing and future Nursing Associations. (3) Nurses to possess certain educational qualifications, and to be trained at institutions recognised as possessing ample facilities for teaching. (4) The period of training not to be less than 3 years and the examinations to be of a uniform standard. (5) Registration of nurses. (6) The formation of a Provident Fund. (7) Recognition that no hospital is properly equipped unless it has its staff of nurses and that in those localities where the people are too poor to contribute to a nursing fund, the State must bear the cost of the nursing staff unless contributions to a central nursing fund enabled the Committee to assist financially. Most of these proposals call for no explanation—(3), (4) and (5) probably require comment.

That nurses should be trained in large institutions possessing ample facilities for teaching is as essential as it is for medical students to undergo their education in large hospitals. Yet I have known hospitals with 10, 20, or 30 beds give certificates that nurses were "fully trained." I have also known larger hospitals, but with a nursing staff so inadequate as to preclude the possibility of "training" give similar certificates. Nurses possessing such certificates have, to my knowledge, so far recognised their inefficiency that they have voluntarily joined larger institutions for further training. I think that nurses are not adequately trained in such hospitals, and that those responsible for persuading young women to undergo their training under such conditions are gravely at fault. In several instances I have heard young women, whose intelligence and sense of duty were high, complain that they were imposed upon and delayed for several years in earning their livelihood, as they found they knew nothing.

Regarding the desirability of a minimum of 3 years' training, I think there can be no question. Those "nurses" who undergo less than 3 years' training are inadequately trained, and they are conceited and dangerous in their ignorance. A 3 years' steady discipline is not a day too much. The best nurses are those who have had the longest training and experience. There is another point; at a certain institution in this City a class of nurses are granted certificates at the end of 12 or 18 months; before they are qualified they provide themselves with an outfit of certain instruments; from many cases which have come under my observation I am satisfied that these women are responsible for a great deal of mischief, imposing as they do on an ignorant public as "certificated nurses." Moreover, the public cannot distinguish between these "short-termers" who have entered their profession by a back door and those nurses who conscientiously go through a 3 years' course; the latter reasonably complain.

Registration of Nurses.

As regards registration, it is, I think, absolutely essential for two reasons :—(1) to enable the public to discriminate and (2) for the purpose of exercising subsequent control. If in Great Britain such a measure is found necessary, it is at least equally so in this country. Were such powers in existence we should cease to hear of such cases as one known to me where a nurse had been responsible for at least 14 deaths from puerperal fever. To return to the scheme, it was fully discussed and the great stumbling block was the reluctance of the separate bodies to sacrifice their individuality and merge themselves into a general body. I believe that in this as in everything else "unity is strength"—you cease to overlap —instead of each "going as you please." A co-ordinated policy guides. If the general public contributed to a central fund humanity as a whole would benefit, for nurses would be trained in large numbers and with greater and more uniform efficiency. Every hospital and dispensary extends its benefits to a radius of 30 to 50 miles, and if each of these were provided with a lying-in ward and a fully trained nurse we could reach the masses in a way which it is impossible under the present system to expect for generations. This brings me to refer to the Dufferin Fund and I venture to make a suggestive criticism. The object of this Association, summarised, is to extend skilled medical relief to the women of India. I believe that if instead of building large hospitals, and contributing to the education of Lady Doctors and Hospital Assistants, it had concentrated its energies at first on the lines I have indicated above, it would have reached a much larger portion of the people than it has at present. If it cannot amalgamate and combine it can at least co-operate now in a common object.

There is an Imperial aspect of a nursing service to which I would simply refer: when plague broke out in this City we remember how impossible it was to get nurses, and Government had to import them at great cost from Europe. With a service, Government would be able in times of war or pestilence to call upon assistance; to provide a reserve I suggested that those certificated and registered nurses who wished to work independently should be allowed the benefits of joining the Provident Fund in return for the right of call on their services.

Infant Mortality.

As regards infant mortality there is no question that the death-rate in the first month is in a large measure due to improper management at the hands of "dhais." With an increase of trained nurses we could reasonably count on a lower mortality. In addition, however, I consider that in the schools of this country instruction in the main principles of feeding the human being from infancy upwards should occupy a prominent place. I refer more particularly to Europeans and Eurasians—the uneducated classes, inasmuch as the majority suckle their offspring, are less in need of instruction. As in Great Britain, so here, the ignorance of Europeans, Eurasians, and many educated natives on the subject of rearing their children is lamentable and they will try experiments

on infants which they would not practice on favourite animals. Recently, an otherwise intelligent woman had, on the advice of her neighbours, reduced the feeds of her 6 months old child to a mixture of one teaspoonful of milk and 4 ozs. of barley water. Another, who had already lost 6 children, was trying to rear a 3 months' infant on curry and rice! Then patent foods, with their simplicity of preparation and wonderful testimonials, are, in unskilled hands, instruments of sickness and death. It is only by education that we can hope to cope with this evil, and it should be the duty of the Educational Department to see that every potential mother knows how to rear a child; to all it would be more useful than music, mathematics, or fancy work.

The conditions in India are not similar to those prevailing in Great Britain. In the latter country every hospital can afford to become a separate entity because each institution has its own private revenue and the public demands efficient nursing as a *sine qua non* of every hospital. In this country it will take centuries to place every hospital in the same position. It is reasonable, I think, to expect the public to contribute towards the maintenance of hospitals in their districts, and we must educate the public to recognise that a trained nursing staff is an essential of every hospital. We want, I think, combination of effort. We require also to persuade wealthy philanthropists to sink self-glorification by contributing to the common good, as in the case of the Dufferin Fund, and to assist in a more active policy for providing trained nurses for the women of this Empire.

DISCUSSION.

Dr. Rajabali V. Patel congratulated Col. Collie on his most interesting paper and thought that such eminent physicians and accoucheurs of Bombay as Col. Collie, Col. Dimmock, Col. Childe and Col. Meyer should approach Government with a petition that there should be employed a trained nurse in every small town and village in India just as they provide a hospital assistant, the nurses to be provided from a central institution in Bombay and other large cities. If this were done an enormous number of lives of mothers, which were now being sacrificed for want of trained nurses, would be saved.

Dr. F. N. Kapadia thought Col. Collie had endorsed the views of the medical profession of Bombay when he said there were many illiterate and incompetent nurses in Bombay who were allowed to nurse people unchecked. Those of them who had practice in Bombay would agree with him that this was an evil which should be nipped in the bud. The nursing profession was just now rising and if something were done for the registration of nurses, the evil would be prevented in time. They knew that there was no Registration Act dealing with medical men in this country, and the result was that the number of unqualified doctors had so far advanced that it had become a matter of the greatest difficulty for the Government to deal with the evil. He thought if anything was done for the registration of nurses, the registration of qualified medical men should naturally follow.

Regarding Infant Mortality the following tables taken from Dr. Turner's report speak for themselves and call for no comment :—

Table showing the Infant Mortality in Bombay from 1897 to 1907.

—	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
1 year and under	7,508	6,279	8,351	13,492	7,768	9,553	8,718	8,981	10,664	11,106	8,276
1 to 4 years	3,825	3,100	4,111	6,894	3,561	3,588	3,512	2,904	3,154	4,851	3,310
Total ...	11,333	9,379	12,462	20,386	11,329	12.941	12,230	11,885	13,818	15,957	11,586

Table showing Mortality amongst Infants under 1 year of age from principal causes during the year 1907 compared with Glasgow.

AGES.	Small-Pox.	Measles.	Diarrhœa and Dysentery.	Premature births.	Debility.	Nervous System.	Respiratory System.	Total number of deaths under 1 year.	Percentage to each period.
1 to 30 days	...	...	54	166	2,427	243	80	3,056	37
1 to 6 months	5	11	247	...	318	693	1,012	2,478	29
7 to 12 months	14	24	444	...	105	301	1,424	2,742	33
Bombay	19	35	745	166	2,850	1,237	2,516	8,276	...
Percentage to the total mortality ...	·2	·4	·9	...	·34	·14	·30	...	...
Glasgow...	...	97	475	458	1,009	321	633	3,185	...
Percentage to the total mortality ...	...	3·0	·14	...	·31	·10	·19	...	...

Section II.

MALARIAL FEVER, PLAGUE, LEISHMAN-DONOVAN-BODY INVASION AND RELAPSING FEVER.

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Presidential Address by Surgeon-General H. HAMILTON, C.B., M.D., V.H.S. I.M.S., President of the Section.

I must in the first place thank the Committee for the honour they have conferred on me, in asking me to preside at this section, though I could have wished that the task had fallen to some one more accustomed to public meetings.

This section deals with diseases that are of the utmost importance to mankind, and it will be admitted that, as regards our knowledge of them, we are still only on the threshold. To us in the Army, malaria is of supreme importance, and much as has been learned about it in the last few years, much still remains to be learned. The discovery of the parasites by Laveran and the discovery of the mode of their conveyance by Ross were very quickly accepted by the medical profession and almost more quickly by the general public, and while in other diseases, tuberculosis and plague for example, other factors besides the parasite are recognised, in malaria the parasite and the anopheles alone seem to be recognised and no modifying factors seem to be taken into account. It is generally taken for granted that the severity is in almost mathematical proportion to the number of anopheles, that if you reduce the anopheles to a tenth, you reduce the malaria to a tenth and so on. And yet there are the Pontine Marshes where, according to Celli, all the requisites for the worst malaria exist without engendering it. Again if you take an irrigated station like Peshawar or like Mian Mir before the closing of the canal, you find that in a year when there are a few heavy showers, in July, August and the early part of September malaria is terrible, while if such showers do not occur, there may be little or no malaria, and yet it is hard to see how the occurrence of these few showers can affect the breeding of anopheles in places where irrigation is used to such an extent. Then again, one usually connects a very heavy rainfall with a very severe incidence of malaria, at least in the Punjab, and yet this year in Rawalpindi there was no very great incidence of the disease although the rainfal was quite exceptional. In other places in the Punjab the heavy rainfall has been followed by destructive malaria. Again, Quetta when I knew it 30 years ago was the most malarious place I had ever seen, and yet it was a bare upland with little water and few trees and so few mosquitoes that no one dreamt of using mosquito nets, and now that water has been brought in and the place covered with gardens and vegetation there is very little malaria. I cannot help thinking that much might be learned from the careful study of abnormal occurrences such as these.

In the matter of the prophylaxis of malaria, the most potent method is to keep out of its way,—to run away from it. This is one of the enemies that it is legitimate for the soldier to run away from. In our Himalayan hill stations we have splendid places to run to. The same principle applies to treatment. The best treatment in case of attack is removal to a non-malarial place. This also checks infection. The climate in the Himalayas after the rains are over up till the weather becomes broken in January or February is one of the sunniest, finest, driest and most bracing in the world, and men attacked with malaria do splendidly in it. But whether it is wise to send a man suffering from malarial cachexia straight up to the cold sunless tempestuous climate of February, March and early April is a question that can only be settled by experiment.

The influence of irrigation on malaria has possibly been better exemplified in Mian Mir than anywhere else. Before the introduction of the canal, it was looked on as a very healthy place as regards fevers. During the irrigation period it is well known that it sufferred terribly. Since the closing of the canal four autumns have elapsed. 1905 and 1907 were rainless and non-malarious and therefore no conclusions can be drawn. 1906 was a year

of heavy rain and severe malaria all over the Punjab, but there was no great severity of the disease in Mian Mir. This last Autumn the rainfall was quite unprecedented and there has been a vast amount of malaria in the Punjab generally. In Mian Mir the incidence among British troops has been decidedly very severe, but the native troops got off very lightly. I think the malaria among the British troops can easily be accounted for by the very defective drainage. I was told at a visit I paid Mian Mir the other day that the whole of the ground in front of the R.A. lines was several times for days together deeply covered with water. Then the station is now suffering for the sins of others that it cannot control. The railway has made excavations round it and brick-fields are converting all the country to the west of it into malarious marshes. Now this is a very important point that affects many of our stations in India. There is no law or power to compel people to desist from insanitary practices in the immediate neighbourhood of our military stations. This is a defect in legislation that should be set right. At present with the best intentions in the world, a District Magistrate or Commissioner is powerless to help.

As the time is short and there is much to be done I will not refer at all to the other subjects that are to be discussed in the section. I will merely welcome you all and call on Prof. Ross to read the first paper.

THE PRACTICE OF MALARIA PREVENTION.

By Major RONALD ROSS, C.B., F.R.S., LL.D., D.S.C., F.R.C.S., I.M.S. (Retired),

Professor of Tropical Medicine, University of Liverpool.

Nobel Laureate.

Every Sanitary Officer who desires to reduce malaria in the district committed to his care is sure to be confronted from the outset by a large number of difficulties with which, perhaps, he does not know exactly how to deal. Although the subject has been considered and debated for centuries, though many additions have recently been made to our knowledge of the disease, and many practical campaigns have been conducted against it, yet so variable are the conditions under which this most widespread of tropical diseases exists that we are still often obliged to hesitate before we plunge into the labour and expense of such an undertaking. A useful purpose may therefore be served if we now attempt to discuss as clearly and practically as possible the difficulties referred to and the best means of overcoming them. Let us ask ourselves what we should do if we were put in the place of this Sanitary Officer—whether he be the sanitary administrator of a country, a colony or a state, or the health officer of a city, a town, a station, or a rural district. And let us consider each question in the order in which it is likely to present itself to him.

1. *The Theoretical Basis.*—Recognising the axiom that doubt is the first duty of the upright mind, we should commence by examining the adequacy of our present knowledge of the disease. Here we must remember that the foundations date back for many centuries. The ancients discerned, not only symptoms of malarial fever, but—as is especially apparent from certain remarks of Varro—that it is connected in some way with marshes and (?) may be reduced by drainage. Of course this of itself does not count for very much, as such public convictions have often proved to be wrong; but most striking confirmation of the hypothesis has recently been brought forward. Coming down to more recent times, we note that cinchona bark became known nearly three hundred years ago as a remedy for malarial fever, and is now universally accepted as the specific—being one of the very few drugs to which this title can be given. This discovery not only taught us how to cure malaria, but, in the hands of Torti, how to distinguish it from other fevers. In 1691 and 1716, Morton and Lancisi further emphasised the ancient opinion that the disease is connected with stagnant water. Still later, attempts were made to explain this phenomenon by the speculation that the stagnant water gives off the poison in the form of a supposed vapour called the *malarial miasma.* In 1880, however, Gerhardt made the startling discovery, by direct experiment, that wherever the poison may originate, it certainly resides in the blood of patients, since such blood is capable of infecting healthy persons. In 1880 also, Laveran showed that this "poison" consists of innumerable minute protozoal parasites of the blood corpuscles; and subsequently Danielewsky and others discovered similar organisms in the blood of many animals. During the last ten years it has been shown by numbers of observations made in many parts of the world that these parasites pass another phase of their existence in certain species of the Culicidæ, which in the natural course of events communicate them from the sick to the healthy; that healthy persons and animals may be infected experimentally in this manner; and that, as a general rule, the Anophelines, which carry the human parasites, breed principally in marshy terrestrial waters. These observations have confirmed the conjectures of the ancients and of our forefathers. Malaria *is* due to a miasma given off by the marsh; but the miasma is not a gas or vapour—it is a living insect. The germs of malaria do not live in the marsh; it is the carriers of the germs which live there.

2. *The Anophelines themselves are the Malarial Miasma.*—The careful thinker may however still ask whether science may not be mistaken in this matter as she is said

to have been mistaken in others. Only those who have studied the subject can reply. We have to deal here with a large body of observations made by many workers. Every phase of the parasites, both in the vertebrate and in the insect hosts, has been minutely figured and described over and over again ; and numerous experimental infections have been achieved. There is nothing exceptional or miraculous in the matter ; and, wonderful though it is, the life-history of the parasites of malaria is simply the same in general as that of numbers of other well-known parasites. Lastly the disease has been abruptly cut short by measures based on these results. It would then be more miraculous if all this accumulated mass of evidence should ultimately prove to be unsound. It is based, not on mere empirical opinion —to which most of the errors falsely attributed to science have been due—but on a very secure microscopical and experimental foundation.

We should therefore, I think, admit the truth of the positive theorem outlined above. But a pertinent question remains. Though the disease is certainly carried by certain Culicidæ, are we sure that it may not also be conveyed in some other manner ? We are not sure : but the more we consider the matter the more improbable does such an hypothesis appear. What are the other agents ? Other insects besides the Anophelines may be suspected. Quite possibly ; but up to the present every effort to incriminate them has failed. Moreover, the known connection of malaria with stagnant water suggests that if any other insect conveys it that insect also is likely to breed in marshes—so that our general principles of prophylaxis will probably remain the same. May not the poison reside in the soil, as people used to conjecture years ago ? It is extremely unlikely, for a number of reasons. Every animal possesses a structure and a life history which fits it to live in a given medium—the fish in water, the beast on land, the bird in air. The parasites of malaria, like other parasites, are fitted by evolution with a complex development enabling them to live in two different hosts and to pass from one to the other. It would be something quite new in parasitology if they could also manage at the same time to live free on the soil, like the beast ; to swim in marsh water, like the fish ; and to rise in the air of the marsh mist, like a bird ? If this be true for the malaria parasite, why not for any other—for every other—parasite ? We cannot be asked to accept such a speculation without proof—mere opinion and suggestion are quite insufficient. Proof would be easy to obtain by the proper experiments on monkeys, bats, squirrels and birds (all of which are capable of infection by parasites closely akin to those of malaria) ; yet no such experiments have been recorded by those who support the conjecture. Nor have we even heard any strong arguments in favour of it ; for the cases cited in support of it are always capable of other explanation. It is perhaps barely possible that malaria may be produced in some other way than by the known route ; but there is an infinity of space between the thing that may be and the thing that is—and the practical health officer need not wander in it.

3. *The Cost of Malaria.*—The next question which will confront him is this one : will the campaign repay the money and trouble likely to be spent upon it ? There are two columns to this account. The cost of the campaign is often discussed ; but not so frequently the cost of the disease. Take for example the case of a military station. Every man on the sick list means a loss to government of so many days' pay ; and every man invalided to Europe or to the Hills means, in addition, the cost of transport. Every death means the loss of a trained soldier—that is, of all the money spent on his training ; and an unhealthy station spells a large hospital and an expensive medical staff. But I fancy that these expenses are small compared to the cost of the disease during active service. Malaria is essentially a relapsing malady. A man once infected and not thoroughly cured is very likely to suffer from relapses when exposed to fatigue (as proved in several ways). What happens then when a regiment " soaked with malaria " goes out of barracks on service ? In such a case a large percentage of the strength is probably infected before starting, with the result that man after man " goes down with fever " when subjected to the hardships of war, and many have to be invalided. Add to this the number of men infected *en route* and we shall understand how greatly the cost of military expeditions in the tropics must be enhanced by the disease—not to mention the loss in military strength. I speak from some personal experience in Burmah ; and may add that French physicians in Madagascar told me of the appalling amount of illness produced in this way among the French forces in that country.

Similarly, in civil towns and stations, we must reckon up the cost of sickness and invaliding among the employés of the state, from the highest officials to the staff of sweepers and the gangs of workmen in the streets. In plantations the cost is often quite crippling to the planter, since from five to twenty *per cent.* of the indentured coolies may sometimes be laid up daily during the busiest seasons. Dr. Bolton, Medical Officer of the Immigration Department of Mauritius, estimates that even in that small island, malaria costs the planters and the coolies something like a million rupees *per annum* ; and I have heard similar complaints from the planters of Assam and the Nilgiris.

What the cost may be to the general civil population cannot be exactly estimated ; but it must be gigantic. Judging from the numerous statistics—such as the admirable Annual Reports of the Sanitary Commissioner with the Government of India, the similar reports of British Colonies, and those of the French in Algeria, etc.—we must infer that, as a broad general average, the disease causes about one-third of the total sickness in most malarious countries. We gather this from the percentages of admissions among the troops, and also from the similar percentages of admission or treatment at the civil hospitals and dispensaries. But these figures must be greatly below the truth. If troops and gaol prisoners who live presumably in sanitary quarters—suffer so much, what must be the case among the general population ?

As a matter of fact, very few of the latter come to hospital unless they are extremely ill ; and nearly all the children remain at home. Fortunately the disease is a benign one ; but the total amount of sickness caused by it must greatly surpass that caused by any other disease (not excluding diarrhœa and dysentery). Indirectly moreover it increases the death-rate to a great extent. For example, in Mauritius, the death-rate runs almost invariably *pari passu* with the spleen rate, from 18·7 per mille to 56·6 per mille (1905-8). In the Seychelles, where there is no malaria, the death-rate remains between 15 and 17 per mille, against an average of 37·4 in Mauritius ! (See my report on Malaria in Mauritius). And similar figures are to be found the world over, that is, the death-rate in malarious districts may be *cœteris paribus*, double the death-rate in non-malarious districts.

But those who have studied the disease from house to house among the poor will know that sickness and death are not its only companions. It tends to infect whole households, not for a few days, but for months or years ; and therefore to incapacitate the bread-winners and to bring destitution with it. I know no spectacle more unhappy than that of a village smitten with an epidemic of malaria. What may we expect, then, in a whole district—aye, or in a whole province or country—smitten with it ? Those who know the disease only by reports or text books know nothing of it.

4. *Economical Questions.*—Such facts at once give rise to certain economical questions of public importance. We might argue that if the disease costs the community such or such a sum, it would be rational to spend a moiety of that sum in attempting to reduce it, provided that we are likely to succeed. Again we might reason as follows : if a State spends such or such a sum annually on its medical and sanitary budget, and if malaria alone causes one-third of the total sickness and a large proportion of the death-rate, would it not be logical to allocate the same proportion of that medical and sanitary budget on the prevention of that single disease ? For instance, if the Medical and Sanitary Department costs Rs. 10,00,000 a year, and malaria causes one-third of the total sickness, would it not be sound to allot Rs. 3,00,000 out of that budget for malaria prevention alone ? Such arguments are perhaps scarcely quite fair, because other diseases must be dealt with, and there are many other claims on the public purse ; but they serve at least to suggest that we may not be quite wise in spending nothing, or only the dregs of the revenue, on so important a branch of public sanitation. It may be bad policy, for instance, to pour out a large sum for the building of a luxurious new hospital, while the surrounding country is left in a condition to poison the people for miles. If the State is justified in spending any money at all on medical affairs, it should surely attempt to spend that money so as to make the greatest possible reduction in the public sick rate. Such considerations may appear too obvious to many; but they will also appear too startling to others; and in either case are apt to be overlooked.

5. *The Measurement of Malaria.*—But the Administrative Sanitary Officer must now examine the other side of the account the cost likely to be incurred by the campaign. Here, if he wishes to obtain the necessary funds from the authorities, he must not rely upon generalities, but must obtain certain specific knowledge in detail. To begin with he is absolutely compelled to form some real estimate of the amount of malaria actually present in his district—that is, of the percentage of persons locally infected. The task is not so simple as some have imagined, but is generally within the powers of a single capable chief—at least with the assistance of the ordinary sanitary staff. I will try to indicate briefly the methods we selected in Mauritius. They are of two kinds—the study of statistics, and the direct examination of children.

Statistics often afford valuable information very quickly, and should not be neglected as sometimes advised. I assume that two sets of statistics will be available—general returns of mortality, and sick returns of hospitals.

The *General Mortality Returns* are almost always reliable within a small fraction of error—at least in any civilised state—so far as they deal with the *total deaths* within each registration area, but, if medical death certificates are not demanded by law, the *classification of deaths*, being returned by non-professional persons, is nearly valueless. From the total deaths however we can extract much information. As already stated, malaria tends to increase the general death-rate, and, moreover, as the late Dr. Meldrum showed for Mauritius, this increase of the death-rate directly or indirectly due to malaria occurs principally in the rainy season. It is therefore advisable to prepare tables showing the population, deaths, death-rate, infantile deaths, deaths under fifteen years of age, and average altitude, for each registration area, if possible during five or ten years. Neglecting small differences (say under 10 per cent.) we compare the total mortality in the several areas, and draw the *prima facie* inference that those with the highest mortality may, *cœteris paribus*, be the more malarious. If the figures are large enough, note also the variations in child and infant mortality (where again malaria tends to exert influence), and also the effect of altitude. If monthly death returns are available, endeavour to find, for as long a term of years as possible, whether there is a marked increase of mortality from the season of first rainfall until a month or so after the end of the rainy season.

This done, we lay the tables aside, and return to the *Reports of Hospitals and Dispensaries*. Here, as the diagnosis is made by medical men or trustworthy assistants, the classification of admissions, or attendances at outpatient departments, is presumably not far from accurate. We now make another set of tables, extracting the total admissions or attendances, and those for malaria alone. A separate column should contain cases of enlargement of the spleen, which, unless there is another cause for this condition, may generally be attributed to malaria. It is advisable also to provide another column for what are called simple continued fevers ; and one for dysentery, which, if very prevalent, tends, like malaria, to yield a rainy-season rise of mortality. We now compare all these tables and will probably be rewarded, if we have used ordinary common sense in the study of them, with a

fairly accurate map of the disease and with sound figures to lay before the authorities.

We are not yet content however, but lay aside the tables for future reference, and turn to the examination of children. A list of all the Government schools, or State-aided schools, being prepared, we visit each after notice to the school-master. The children are collected, and then passed quickly one by one before the examiner, who determines whether each has, or has not, enlargement of the spleen and liver, while an assistant records his conclusion. The work can be done at the rate of a hundred children an hour. If the medical officer wishes it, more detailed information may be obtained by recording, not only the mere existence of enlargement, but the degree of it. I suggest that four degrees of size of spleen be recorded: no enlargement, and slight, medium or great enlargement. Of course this will be a very rough estimate for which we may perhaps assume that slight, medium or great enlargements imply enlargement to three, six or nine times the normal size respectively (it would be useful if more exact ratios could be suggested). From these figures we may obtain what may be called the *average spleen* of the school, by adding together the number of children with no enlargement, three times those with slight enlargement, six times those with medium enlargement, and nine times those with great enlargement: the sum being divided by the total number of children examined. This process is, however, by no means necessary, and in fact introduces the personal element of the examiner; but it assists the simple spleen rate because it adds a rough estimate of the average degree of enlargement present. Thus, for 30,137 children examined in Mauritius, we judged that the average spleen was something like 2·54 times the normal size; while the percentage of children with enlarged spleen amounted to 34·6 per cent. of the total. A large spleen rate with a small average spleen suggests many recent infections, while the converse suggests old ones. It has been said that extreme splenomegaly does not occur in malaria; but this is not the case. Both in Greece and in Mauritius, where there is probably only pure malaria, I found splenomegaly as great as I saw in the worst Kala Azar country in Assam. But in both of the former, enlargement of the liver, which is such a feature of Kala Azar, was almost entirely absent. My brother, Dr. E. H. Ross, tells me that in Egypt enlargement of the liver is very prevalent among the children, but is not ascribed to Kala Azar, cirrhosis being found *post mortem.* I think then that for a rough test children with enlargement of both spleen and liver may be excluded; but, pending further work on this subject, it would be safer perhaps to leave such matters to the good sense of the local examiner. As a general rule the spleen test, though by no means a rigid one, is so easily applied to large numbers of children that it gives a very accurate criterion.

Examination of the blood of children for the parasites is a stricter one, but is far more laborious. Few health officers can have the time, single-handed, to undertake it. Yet, unless we deal with large numbers of children, what is called "random sampling" is likely to lead to considerable statistical error. An hour suffices to ascertain the spleen rate in a hundred children; but to examine their blood exhaustively would occupy several days' hard work. Yet in either case the statistical error with so small a number of children may amount to nearly 15 per cent. Moreover, the search for parasites demands practice and skill as well as labour, and the organisms are frequently over-looked. For example, I have in Liverpool slides of blood of 102 Greek children. These have been examined by successive batches of our students at the University, and we frequently detect the parasites where they had been overlooked previously. The very last examination disclosed the fact that four more of the children were infected in excess of the number previously found (36 out of the 102). In short, as a practical mode of measuring malaria the parasite-rate (as it may be called) is too laborious for application to such large numbers of children as we must examine in order to avoid statistical error. It is, however, invaluable for *verifying the spleen test* and that is its proper position in the practical antimalaria campaign.

Of course for a large district, the spleen test, facile as it is, becomes too much for one man, and the assistance of other medical men and of medical subordinates must be called for. In this manner, the medical and sanitary staff of Mauritius, with such help as Major Fowler, R.A.M.C., and myself were able to render, examined over 30,000 children in a few weeks and obtained statistics which, I hope, have definitely measured and located the disease in that island. The same can be done elsewhere; and the figures so obtained, combined with others given by official returns, will serve, not only to lay before Government, but to test the results of future work.

(It may be useful to add here a note about statistical error. If we examine 100 children in a school and find 50 of them infected we have no right to assume that the same percentage of children outside the school are infected. I have found the following formula easy to remember. The percentage of error cannot be greater than $100 \div \sqrt{\frac{n}{2}}$, where n is the total number of children examined. Thus if $n = 100$, then as the square root of 50 equals about 7, the percentage of error cannot exceed about 15 per cent. If we examine 1,000 children the error cannot exceed about 4·4 per cent.)

6. *General Rules regarding the Preventive Measures.*—It should be observed from what has been said that the measurement of malaria in a District will cost Government little or nothing beyond, perhaps, the ordinary travelling expenses; and will involve but small additions to the work of officials. The measurement being completed, the sanitary department is now in a position to commence the campaign, if such is decided upon, *without further investigation.* I say so advisedly, for reasons which will appear presently.

Fortunately we have many weapons against malaria; and they have been so frequently described and discussed that it is unnecessary to labour the point here. They may be classified as follows: (*a*) *parasite reduction* by the use of quinine; (*b*) *mosquito-reduction* by drainage and

other means; (*c*) *subsidiary measures*, such as wire gauze, segregation, public instruction, and so forth. Each measure has its own advocates; but after ten years' experience we may, I think, venture to lay down without further discussion the following rules regarding the special applicability of each :—

(1) All antimalaria measures are good and useful; and each should be employed in its proper place.

(2) For cities, towns, large stations, and other dense populations, mosquito-reduction will probably be the most appropriate measure, because in such, (*a*) the cost of drainage benefits a large number of people and can be better borne by them; (*b*) its cost will probably be less than the cost of effective quinine distribution among so many; (*c*) the measure will tend to remove other diseases and annoyances besides malaria; and (*d*) it can be carried out by the authorities on their own initiative, without making demands on the populace to take drugs, use mosquito nets, and so on.

(3) For scattered populations, small villages, and rural areas, we must generally fall back upon quinine, because the cost of drainage (which is as great, or greater, in the country as in the city) is likely to prove too much in comparison with the benefits likely to accrue from it.

(4) In the presence of severe malaria, both mosquito-reduction and parasite reduction should be employed together; and the subsidiary measures are to be used in special cases.

In considering this list, the Sanitary Officer will always ask, where is he to begin? What must he do first? The answer may be put in the form of the fifth rule :—

(5) Begin with those measures which can be immediately adopted, that is to say, as a general rule, with the cheapest ones.

Neglect of this rule has led to many disappointments. I have known of cases where the Sanitary Officer has begun at the wrong end, as for instance by demanding of Government an enormous sum for draining large marshes, and this, often, without any attempt at preliminary enquiries regarding the amount of malaria, or the actual effect of the marsh referred to. Government has wisely refused and the Sanitary Officer has then sat down "sulked" and done nothing. But much can be effected for a very small expenditure. I will therefore try to deal with the points in order of practicability.

7. *Parasite Reduction and Spleen Registers in Schools.*—We know that native children are the principal homes of the parasites of malaria. Now most tropical countries are advanced enough to possess numerous schools—either supported entirely by Government or assisted by "grants-in-aid." These can be utilised at once, without any delay, for a double purpose—(1) for the treatment of sick children and (2) for the *continued* measurement of malaria. I have recommended the following procedure for Mauritius—

(1) Every schoolmaster should keep a "Spleen Register" of the children in his care.

(2) Every school should be visited on any convenient date once a quarter, either by the sanitary officers, the district medical or other medical officers, or by trustworthy medical assistants.

(3) The Inspector should examine as many of the children as possible at each inspection, and should note in the Register, opposite the name of each, whether he is suffering from enlarged spleen or fever, and what dosage of quinine should be given to him during the next three months.

(4) The master should endeavour to carry out his directions to the best of his ability by giving the drug as ordered.

I will not presume to lay down the best prescriptions for such treatment. My own personal views, subject to correction, are as follows. I agree with Celli that small daily doses are preferable to large ones, once or twice a week —most certainly so in the hands of non-professional men. I always maintain also that the drug must be continued for months if the parasites are to be extirpated in the patient. Freshly made pills seem to me to be the best and most economical form, and the smaller children can be bribed to take them by the present of a sweet after the dose. Generally speaking then, a small dose in the morning when the child comes to school given every day on school days, or every day for the first fortnight in every month, seems to me the best procedure.

The following points, however, are almost vital. Do not attempt to give the medicine to healthy children—which will only set the parents against the treatment—unless a demand is made for it. And do not discontinue the drug too soon—which will only discredit it. Of course small difficulties will arise; but these will disappear under steady pressure and determination.

The pills should be freshly made and supplied, not less frequently than once a month, in assorted sizes put up in large separate canisters. The daily dosage which I suggest is about one grain of the sulphate (or its equivalent) for every three years of age. We must not forget the canister of sweets (or their equivalent).

The expense of this measure will not be so large that many governments will decline it. The drug must of course be provided, and the Medical Store Department may require additional labour to make and despatch the pills. But after long consideration I think that this method of quinine distribution is probably the best and most economical one for the tropics. Its benefits are likely to be very great—for in fact we are here applying prevention and cure combined.

We are doing something else however—namely, providing for the accurate measurement and registration of the disease, quarter by quarter. After each visit, the Inspector should briefly report the number of children examined by him and the number found with splenomegaly. The reports will indicate better than anything else the local prevalence of the disease and also its increase or decrease.

8. *General Quinine Distribution in Badly Infected Areas.*—We must carefully distinguish between the use of quinine for *prophylaxis* and for *treatment* respectively. For the former the drug must be taken constantly by

healthy people in the hope of warding off infection which has not yet occurred. Briefly, anyone who seeks to persuade thousands or millions of healthy people to adopt such a course will be embarking on a very hopeless and also a very expensive undertaking. In fact it can be done only exceptionally, as for instance amongst troops. But it is quite otherwise with the issue of quinine for treatment. Here the patient is sick and probably poor, and will grasp at any remedy provided that he is not put to too great expense and difficulty in obtaining it. It is often stated that even the sick will not accept it; but this is due solely to the fact that it is not distributed properly. Patients are compelled to wait for hours at dispensaries and are then given a scanty dose or two—quite insufficient to influence their case at all. I have no time to argue the point in detail; but must insist on the following rule:—If you wish to influence the disease seriously by quinine you *must deliver it at the houses of the poor*, either for nothing or for a very small payment. This is not really expensive; and we should proceed as follows:—

Select the most malarious area at hand, and appoint a trustworthy dispenser for the work. Give him a large wallet full of assorted quinine pills and direct him to deliver them from house to house to all who wish to take them. Moreover enough of the pills to suffice for a daily dose (say 5 grs. for the adult) during a fortnight should be given. In this way the dispenser can visit say fifty houses a day, and as he need visit each house only once a fortnight, he can generally deal with five or six hundred houses. A large and severe epidemic at Phœnix in Mauritius was absolutely cut short in two months last year by this procedure, combined with drainage. For the whole of Mauritius, with its population of 375,000 and its spleen rate of 34 per cent., I advised five such dispensers, costing only Rs. 6,000 *per annum*, exclusive of the quinine.

On consideration, I think that this organisation (as regards schools and dispensers) practically sums up what can be usefully done in the way of public quinine prophylaxis in the tropics. My estimate for the cost, preparation and distribution of quinine in Mauritius was Rs. 33,600, per annum; but that island possesses many planters' dispensaries. A wider distribution, as at Panama, will of course cost much more; but not every district has such funds at its disposal.

9. *Early Partial Mosquito-Reduction Advisable.*—But I doubt whether any quinine distribution which can be practically carried out will of itself suffice to break malaria permanently in the tropics, whatever it may do in temperate climates like Italy and Greece. My reasons are that in the latter the breeding season of Anophelines is comparatively short, leaving two-thirds of the year for the treatment and recovery, perhaps complete, of patients, whereas in the tropics, the insects may often breed nearly all the year round, and may therefore constantly cause reinfections over and over again, so that treatment must be continued assiduously and indefinitely if recoveries are to keep pace with new cases or with the reinfections. Given an intensely malarious marshy area, I doubt whether any amount of cinchonisation will suppress the disease without a certain amount of drainage. In Ismailia the former failed. The fact is that with swarms of carriers in every direction it is as difficult to put down the disease as it would be to put out a fire so long as someone else continues to relight it.

By this time the Sanitary Department has obtained a clear idea of the distribution of the disease; and may now proceed to consider the possibility of the more obvious minor works of mosquito reduction.

10. *Extensive Preliminary Investigations not Required.*—The local species of Anophelines have now been identified in most countries; while in many the species capable of carrying malaria have been distinguished. If this has not been done, it is advisable to have the work carried through by a competent observer; but there is no reason to hold up mosquito reduction until his researches are complete. For reasons already discussed we may assume that one of the local Anophelines is the culprit, and the method of dealing with all are broadly similar—being in fact developments of those used by the Romans. In Ismailia the disease was expelled before the culprit was definitely detected; and so also, I believe, in Panama and the Federated Malay States. The local habits of the insects will be best ascertained during the progress of the campaign itself, so that there is no real necessity for delay.

11. *The Main Theorems of Mosquito Reduction.*—I must enumerate these as quickly as possible. The principal one is that malaria must decrease if the number of carrying agents falls below a certain level. To understand this we reason as follows. It is easy to imagine that in a country swarming with Anophelines every person may become infected (which probably actually happens not infrequently). On the other hand, we can imagine that in a country where very few Anophelines are left the disease may die out entirely (which has occurred in Great Britain). Hence, between the two extremes, there must be some limit or standard in the number of the carrying agents required to keep the disease at the same level. Or to put it in another way; any disease must increase if the number of new infections is in excess of the number of recoveries; and must decrease if the converse holds. Now in malaria the number of new infections cannot keep pace with the recoveries unless the carrying agents are numerous enough to produce enough of the former. The subject can be dealt with mathematically (*vide* my Report on Malaria in Mauritius, published by J. & A. Churchill, London, for the Colonial Office); but we are concerned here only with the result. That is, that *complete extermination of the insects is never demanded and that a diminution is sufficient.* We can have no misgivings as to this conclusion, because every year nature makes the experiment before our eyes in the simultaneous decline of malaria and Anophelines together at the end of the rainy season.

The second main theorem is that by the laws of chance, however far an insect may occasionally wander from its breeding place, the majority of insects bred there will tend to remain near it. This has been

ably dealt with mathematically by Professor Karl Pearson; but nature herself demonstrates the same theorem. For, if it were not true, the mosquitoes would be uniformly diffused like a gas. The practical conclusion is that *the breeding places nearest to habitations tend to be the most dangerous ones*, and should be the first to be dealt with. A puddle near at hand may cause as much mischief as a large marsh a mile away.

Other points of importance are (1) that, as the same organization suffices to deal both with the Anophelines and the Culicines, we may as well include the latter in the campaign; and (2) that, following the general principle recently suggested, it is always advisable to begin by attacking the smaller breeding places—in other words, "minor works before major works." Before committing the State to the expense of draining large marshes, see what can be done by removing the small collections of water near houses.

12. *The best Organisation for Mosquito Reduction.*—The organisation now described is that which has been recommended for Mauritius. I have ventured to call it the "best" one because it was designed only after careful consultation with the medical staff of that Colony, led by the capable Director, the Hon'ble Dr. Lorans; and I use the epithet only tentatively, of course. A discussion on this very important point would be most welcome.

(1) The head of the Sanitary Department can always organise the preliminaries of the campaign, such as I have outlined above, by himself; but will need a special assistant when the work develops. For a single town or station, a trustworthy sanitary inspector, placed under the local sanitary authority, ought to suffice; but a colony or province will require a well-qualified medical man, zoologist, or, perhaps, engineer. His duties will be to direct and supervise all the operations, under the head of the Sanitary Department; to collect the statistics, and to prepare the annual malaria report (which will be suggested presently). I conclude that this official is absolutely necessary if continued success is desired. Without him, efforts are likely to be only spasmodic; the campaign may be abandoned after a time; money will be wasted, and the whole business will be discredited. In fact, this is just what has happened in several cases—an energetic medical officer has commenced a campaign, which has been dropped on his leaving the station.

(2) Under this special "malaria assistant or director", it is necessary to appoint a certain number of intelligent subordinates who may be called "*Malaria Inspectors*" (an excellent name used in Mauritius and suggested by Colonel Peterkin, R.A.M.C., is "*moustiquier*"). Each man, after a sufficient training in the habits of mosquitoes and allied matters, is placed in charge of a given area of, let us say ten square miles, more or less. His principal duty is to seek out and know the breeding places of all kinds of mosquitoes within that area; but he must also keep an eye on the working gangs, become well acquainted with the houses and villages, guide the quinine dispensers, and, in general, be the lieutenants of the "malaria director" within the area allotted to him. Major Fowler and I trained ten such men in Mauritius in a few weeks. They proved absolutely invaluable, and since we left have been in constant demand by the planters, under the capable supervision of M. d'Emmerez de Charmoy, the head of the operations. Such men, also, are absolutely necessary for a well conducted campaign. Any intelligent native will suffice. For the whole of Mauritius (705 square miles) I recommended fifteen moustiquiers altogether, costing Rs. 4,560 a year; but labour there costs nearly twice as much as in India. One man generally suffices for a single town or station and for a considerable area round it.

The actual labour should be performed, I think, by workmen organised in small "malaria gangs" of about three men each. This is convenient for many reasons. One of the men should be the headman of the gang and receive a little higher salary; he should direct the others, but must also do manual work himself. The men should be of the gardener class, accustomed to labour on the soil. In Mauritius the three men together cost Rs. 50 a month; but in India their pay will be less. Each gang is allotted a given area, within which they must constantly carry on all the necessary "minor works"; that is, clearing water channels and drains, rough-training streams, dumping in holes and pits, and draining small marshes, waste waters and so on. In the dry weather their attention is turned largely to the reduction of Culicines round houses, by the removal of tins, bottles and other rubbish, the examination of cisterns and tanks, filling of holes in trees, etc., in fact, all the well-known anti-mosquito work. As I have frequently urged, these gangs make an invaluable addition to the ordinary staff of the Sanitary Department. Specifically employed for a given object, their work results in a general "cleaning up" of a locality, as well as in the approximate realisation of the anti-mosquito campaign.

For the whole of Mauritius, exclusive of the sugar estates (which have their own labour), I recommended, after careful consultation with the Medical Department, 109 gangs altogether, consisting of a force of 327 men, and costing Rs. 65,400 a year. But this is a tentative estimate for a very thickly populated country with high labour wages. The cost, with that of the necessary implements, averages about Rs. 100 *per annum* for each square mile; about one rupee and a half per annum for every house; and less than a fifth of a rupee per head of population.

My estimate for the annual cost of the whole organisation for Mauritius, including salaries of the director, 5 quinine dispensers, 15 moustiquiers, and 327 workmen, cost of quinine, implements, office, travelling expenses and working margin, came to a total of Rs. 1,35,000 a year; being 1·21 per cent. of revenue and less than a fifth of the money now spent on the Medical and Health Department. The disease, however, must cause a third or more of the total sickness in the Colony, and appears to influence the death-rate to a very large extent.

13. *Minor Works and Major Works.*—I define as "minor works" all those petty works for mosquito reduction which can be done without employing the services of an engineer, such as the duties of the malaria gangs

already mentioned. On the other hand, "major works" are those which require an engineer, such as the drainage of large marshes, provision of proper outfalls, and so on. As a rule, from principles already stated, the minor works will be the more numerous and perhaps important; but major works may sometimes be required. Great care must be taken in recommending the latter, and this should not generally be done unless the case for them is quite clear—that is, unless other measures have failed after due trial, or are never likely to succeed. We must always distinguish between a marsh in the midst of a crowded locality (which frequently *must* be removed) and one in the open country with but few houses near it. To demand a large expenditure for the latter is absurd, and it would be cheaper to remove the houses or try other measures. The expenditure caused by major works must of course be looked upon as additional and capital expenditure, care being taken to make due allowance for "maintenance."

14. *Further Notes on the Organisation.*—(1) Every year the Sanitary Department should submit a careful report on the progress and effect of the campaign. It is absolutely essential that the spleen rates in schools, obtained in connection with the quinine distribution, should be entered in the report every year, together with other measurements of malaria made at regular intervals. Without such repeated measurements, Government will never know the return which it is receiving for its outlay, and the campaign may therefore come to an abrupt end at any moment.

(2) It is sometimes a nice question to decide whether it would not be cheaper in the end to treat a given area by a major work instead of continuing to deal with it by minor works. Such questions can be answered only after local study.

(3) The issue of advice and warnings to the general public is often urged. It does no harm, but seldom, of itself, does good. Experience proves that the public disregards such suggestions, and, in fact, the individual often cannot take the advice offered. Malaria prevention on a large scale is not a matter of personal prophylaxis, but of concerted action—that is, of Government action.

(4) Special legislation is not really often required. A few ordinances on the lines employed in several British Colonies, and given (with legal assistance) in my report on Mauritius will be useful.

(5) As sanitary intelligence advances, we may perhaps hope to see much greater attention given to malaria prevention in all tropical administration. For instance, makers of railways should not be allowed to poison whole villages by leaving undrained borrow pits along the line. Irrigation should be scrutinised in the same interest. Municipalities should not be allowed to provide the streets with ill-made gutters. Building laws should be made much more strict, and the existence of swarms of mosquitoes in towns should be looked upon as evidence of bad management.

15. *Conclusion.*—The procedure and organisation which I have attempted to sketch out is mainly that recommended for Mauritius; but this does not mean that it is, by any means, an organisation suitable only for that island. In fact, all the details have simply been selected and developed by the chief medical staff of Mauritius and by Major Fowler and myself from similar details of the campaigns conducted in Sierra Leone, Panama, Ismailia, Federated Malay States, Ceylon and elsewhere. Any further hints on the various points raised, or notes of actual experience in the field, would be of assistance in further developing this vital matter of organisation.

THE INTIMATE PATHOLOGY OF MALARIA IN RELATION TO BLACK-WATER FEVER.

By Capt. S. R. CHRISTOPHERS, M.B. I.M.S., and Dr. C. A. BENTLEY, M.B., D.P.H., D.T.M.

The malarial origin of black-water fever is very generally admitted; but there is still a considerable amount of misconception regarding the relationship between malaria and this disease.

In the first place it is necessary of course to disabuse minds entirely of the idea that in an attack of black-water fever we see anything of the nature of a malarial paroxysm; Koch once and for all disposed of such a view.

Perhaps a good analogy giving some indication of the kind of relationship with which we are dealing is that of the dependence of delirium tremens upon alcoholism. A single alcoholic bout may be pushed until it causes acute alcoholic poisoning and perhaps death; but no single indulgence, however excessive, will produce delirium tremens. Again a man may drink frequently and heavily but still not suffer from delirium tremens; or he may get alcoholic neuritis, cirrhosed liver and a number of other effects of chronic alcoholism, without delirium tremens having necessarily supervened. Delirium tremens we know to be the result of continuous and heavy drinking pushed to a certain excess; but this condition does not necessarily result in every case; and there is very often, quite apart from alcohol, a precipitating cause at work, such as the effect of a broken leg.

So in regard to black-water fever we can say that it is never so far as we know a result of one or two attacks of malaria, however severe they may be. It is a new condition, the outcome of malaria intoxication under certain circumstances. In the limits of our present paper we cannot do justice to a description of the very definite circumstances in regard to malaria which bring about this condition. We may note only that we require:—

(*a*) A person highly susceptible to malaria, whether this show itself as "fever", or as long-continued infestation, with perhaps only vague

and uncertain symptoms, unrecognised but none the less dangerous.

(*b*) Conditions as regards malaria which lead to the certainty of almost daily inoculation with sporozoits. Such conditions are of widespread occurrence on the malarious coast of Africa, but as all will probably acknowledge do not occur in ordinary life in the plains of India.

(*c*) These conditions must act continuously for a certain time,—if exceedingly intense or in the case of a very susceptible person during six months, or in very rare instances three months, but usually for a period of about eighteen months or two years.

It has been frequently suggested that black-water fever is due to the action of a malarial toxin which for some reason is liberated in specially large amounts. It has also been suggested that long continued malaria or some other condition leads to changes in the resistance of the red cells or to alteration in the salt content of the plasma. It has been suggested too that the disease is not really related to malaria at all, but due to a special parasite. With regard to the first idea, there is the difficulty of accounting for the absence of the condition in the most severe types of actual malarial attacks, unless these occur in a subject already prepared by residence. The fact too that the condition seems only to arise after a long continued intoxication and after a kind of preparation of the human organism suggests not so much the action of a toxin elaborated by the parasite as some accident in the course of immunisation.

With regard to the other hypotheses we need only say that a study of the disease does not support them.

Before proceeding further it is desirable to draw attention to some points in the pathology of malaria and to conditions regulating blood destruction in general.

Let us consider for a moment some of the special features of the different species of the malaria parasite, as exhibited in the course of human infections.

We are concerned with three species :—

The Quartan,
The Simple or Benign Tertian,
The Malignant Tertian.

Everyone is familiar with the differences between these three types and the broader characteristics of the respective infections produced by them. But there are certain points which appear to have a special importance in connection with the matter under discussion, and it is necessary to refer to them, particularly as the study of malaria is not often approached from the point of view we are indicating.

In malignant tertian infections some of the most noticeable features of the condition are :—

(*a*) The absence from the peripheral blood of sporulating bodies, and the disappearance of parasites from this situation once they have reached a certain stage of their existence.

(*b*) The tendency for the accumulation of the infected corpuscles in the visceral capillaries.

(*c*) The frequently recorded marked alteration o the infected red cells—(globuli rossi change).

(*d*) Specially active phagocytosis of infected red cells.

(*e*) The great tendency for infections by this species of parasite to produce pernicious symptoms, often simulating definite organic disease as of the brain, (comatose and delirious forms), the intestinal system, (algid, choleraic and dysenteric forms), the lungs, (pneumonic form), and according to some observers other manifestations such as a form of pleurisy, etc.

In infections by the quartan and simple tertian parasites on the other hand we find :—

(*a*) Sporulating bodies appear very frequently in the peripheral circulation.

(*b*) There is not the same tendency for infected red corpuscles to be held up in the visceral capillaries.

(*c*) Phagocytosis of infected red cells is exceedingly rare, Thayer stating that he has never observed it.

(*d*) Pernicious attacks are rarely if ever encountered in the course of infection by either of these two species of parasite.

Are the different phenomena observable in the case of infections by the malignant tertian parasite for example inter-related ?

And again are the different effects produced by each species of parasite due merely to the characteristic behaviour of these parasites, or is there some fundamental pathological principle underlying them all?

Let us before answering these questions turn to the consideration of certain data connected with blood destruction in the body. If we add some hæmolytic agent to a suspension of red blood corpuscles in vitro, we shall under suitable conditions produce a solution of the cells. This being so, one is tempted to think that the profound destruction that may follow the injection of a hæmolytic agent into the body, may be due to a simple solution of the red cells, resulting from the direct action of this hæmolytic body such as occurs in the test-tube. But this conception does not accord with the facts.

By injecting a goat with dog's blood we prepared in the ordinary manner a hæmolytic serum which under suitable conditions showed a strong solvent action for dog's corpuscles. The injection of a large dose of this serum into dogs was followed by a rapid, profound and progressive anæmia resulting in death. Here then we might be tempted to suppose that there had been a solution of the dog's red cells. In the case of many animals, however, in spite of extraordinary anæmia brought about within a few hours by the toxic serum there was no evidence of red cell solution. Hæmoglobinuria did not occur, nor did a careful examination of the blood show the presence of hæmoglobinæmia or shadow corpuscles. Moreover, though the tissues on *post-mortem* examination show great pallor, there was none of the yellow staining characteristic of the condition mentioned later, in which solu-

tion of the red cells had actually occurred. Further examination of the organs showed that the rapid and enormous blood destruction was not of the nature of solution at all, but was due to an extraordinary phagocytosis of red corpuscles and the holding-up of these blood elements in the capillaries, notably those of the spleen and liver. The condition of affairs in the different experiments could be seen to vary from some congestion of an organ associated with red-cell phagocytosis to the most extraordinary condition where the whole spleen was converted into a mass resembling a thrombus.

But by a regulation of the dose of the serum we found that another result could be obtained. A lesser dose produced as before severe and rapidly progressive anæmia with a similar holding-up and phagocytosis of red cells in the visceral capillaries. But very often when the anæmia had progressed for twenty-four hours or more there supervened a new phase; for the first time the plasma now showed free hæmoglobin, the urine became hæmoglobinous and the tissues after death showed the characteristic yellow staining so well seen in black-water fever. In this phase too in blood from the hepatic and renal vessels we found shoals of stromata and decolorised red cells.

Two distinct processes may result, therefore, from the action of a hæmolytic serum *in vivo* :—

(*a*) An easily produced and constant effect due to the holding-up in the organs and ultimate phagocytosis of red cells;

(*b*) And a condition which may or may not supervene, characterised by actual solution of the cells within the blood stream, the accompanying hæmoglobinæmia being followed by the occurrence of hæmoglobinuria.

For convenience of description and because at the time no suitable names existed for these two-newly recognised processes, we termed them, respectively, *Erythro-katalysis* and *Lysaemia.* These terms, although not perfect, appear to answer their purpose for the present.

Why then, we may now ask, do we not get hæmoglobinuria in the course of an ordinary attack of malaria, however severe? Because we can say, it must be that the destruction of red cells in malignant tertian malaria is not due to *Lysaemia*, a condition which would produce black-water fever, but to *Erythro-katalysis.* How far erythro-katalysis is concerned in blood destruction by simple tertian and quartan malaria we do not know, but here we seem to have another factor, for in these infections disruption of the red cell occurs only when it no longer contains an appreciable amount of hæmoglobin.

There appears, therefore, to be little doubt that the action exerted by the malignant tertian parasite upon the red cells differs in a marked degree from that exhibited by the parasites of the other two species. And this peculiar action is chiefly demonstrated by the induction of a condition which renders the corpuscles specially-susceptible to destruction by erythro-katalysis, so leading more than in the other infections to a holding-up of infected cells in the visceral capillaries.

The tendency towards an extensive phagocytosis of damaged cells is also in accordance with the general pathological principle. The absence of sporulating bodies is also obviously due to the same; and we could, if time were not pressing, show that the change in globuli rossi corpuscles, a change which we have noted and which is well known to be very common in malignant tertian malaria, is a condition exactly resembling that brought about by erythro-katalytic toxins, such as we have used experimentally.

And similarly herein appears to lie the possible explanation of the association of the pernicious attacks with the malignant tertian infections, perniciousness being the result of the stasis produced and the subsequent clogging and infraction of the capillaries. The generally severer and more lasting effects of malignant tertian infections, their more insidious course, the frequently anomalous symptoms, the continuance of fever for days in spite of specific treatment and when parasites cannot be found, should make us give due consideration to the fact that in this disease we may have a condition of erythro-katalysis produced, similar to that which studied experimentally can be seen to lead to quite marked organic disease. (We may remark here in parenthesis, that experiments on dogs have suggested to us the possibility of erythro-katalysis in a marked degree being concerned in the causation of post-hæmoglobinuric and certain other anomalous fevers, such as the "symptomatic fever" of Kelsch and Keiner, in which a febrile condition exists uninfluenced by quinine and apparently unrelated to any specific cause, but associated almost invariably with evidence of continued blood destruction.)

What relation do these observations bear to the causation of black-water fever?

We have previously referred to the fact that by immunising an animal of species A against injections of the red corpuscles of species B, we produced in A a serum capable of dissolving the blood cells of B in vitro, and when injected *in vivo* of producing symptoms under certain conditions closely resembling those of black-water fever. It may be asked whether it is possible to produce a similar effect by injecting an animal with blood from another individual of the same species? This is possible, for Ehrlich and others have produced in this way a number of different iso-lysins. Still further pushing the question we may ask if it is not possible to immunise an animal against its own blood cells? This has been attempted, but it is not easy, apparently because of certain regulating powers possessed by the organism, which largely serve to protect it from such a condition. Nevertheless Ehrlich records that he did once produce an auto-lysin in this way. Under pathological conditions, however, we often meet with effects that we cannot produce experimentally and the occurrence of auto-lysins as a result of disease is very probable.

What actually happens during the process of immunising an animal of species A to the red cells of an animal of another species B? Metchnikoff has investi-

gated this question and states as the result of numerous experiments that whenever foreign blood cells are injected into an animal, the primary phenomenon to be observed is an extensive phagocytosis or resorption of the foreign blood elements. In attempting therefore to produce an auto-lysin experimentally we endeavour by some means to force an organism to deal repeatedly with its own red cells in the same manner that it would act towards foreign blood corpuscles; in other words, we attempt to stimulate the resorption of a large number of an animal's own blood cells.

In black-water fever, as we have already indicated, we have reason to believe that we are not dealing with the effects of a toxin elaborated by the malarial parasite, but with the action of substances produced by the human organism itself, in other words, with the effects of an auto-lysin. And if a human auto-lysin is to occur, can we think of any disease condition more likely to produce it than malaria? Malaria actually gives rise within man's body to the very condition we try to bring about in the attempt to produce an auto-lysin experimentally. Under the circumstances which appear necessary for the occurrence of black-water fever, the peculiar character of which we have briefly indicated, it is obvious that repeated and persistent blood destruction and resorption must result, and we see again that if our hypothesis, which is only hypothesis, be the true one, why the malignant tertian parasite with its special action upon the red cells and consequent stimulation to their phagocytosis, should above all be the one concerned in the causation of black-water fever.

All this is of course hypothesis, but it may serve its purpose of indicating in a very broad and general way how black-water fever may be malarial in origin and yet not be malaria.

DISCUSSION.

Prof. Musgrave said that he had been greatly interested in the able and lucid paper on black-water fever, and in the phenomena of hæmo-katalysis and lysæmia described by Capt. Christophers and Dr. Bentley. He had no time to personally study the subject, which was vast and complicated, worthy of the importance attached to it, and difficult to study, it required as much or more time to criticise.

Dr. Newell said :—I am glad that both Drs. Christophers and Bentley regard black-water fever as of malarial origin and are inclined to put the blame on to the malignant tertian parasite. My experience of the disease has led me to hold the view for some time that black-water fever is only to be found in patients who have had malignant tertian malaria. In favour of this view is: (1) that this parasite can and has been found prior to the occurrence of hæmoglobinuria, (2) that the absence of its finding when hæmoglobinuria has occurred is in accordance with the habit of the malignant tertian parasite to disappear from the peripheral blood, (3) in marked cases of black-water fever the temperature chart is that of a malignant tertian infection, (4) the period of usual prevalence is that of malignant tertian parasite. How does the condition of hæmoglobinuria arise? The idea of a toxin, I am glad these observers say, may be dismissed and I would add that other observers have searched for a toxin and failed, and blood from an infected case has failed to reproduce the disease. Quinine as the main factor in the production of the condition may also be dismissed as it can occur apart from the taking of any quinine. That quinine bihydrochloride will have less tendency to precipitate it than the sulphate I deny, as I have had a case occurring on the taking of quinine bibydrochloride and also when quinine bihydrochloride was intermuscularly injected, later the hæmoglobinuria recurred. In my opinion black-water fever only occurs with malarial tertian parasite and then in such cases only as a result of congestion of liver being present. The congestion of the liver, in my opinion, would appear to be a necessary condition for the condition of hæmoglobinuria to occur. In ordinary benign infections the liver is able to deal with the destroyed blood corpuscles and the hæmoglobin thrown out into the plasma. But in malignant varieties the liver is highly congested and its power to deal with the hæmoglobin is impaired, and so what more natural than that the hæmoglobin should pass out through the urine? In my opinion in the malignant tertian infections hæmoglobin frequently passes out into the urine in small quantities not sufficient to call the case black-water fever, and also that it is extremely difficult in some cases of malignant tertian malaria to know where malignant tertian ends and black-water fever begins. Black-water fever is,in my opinion,only malignant tertian fever with a superadded biliary condition owing to which the liver is unable to deal with the hæmoglobin. This view of black water fever of mine is quite in accord with the so-called relation to quinine. If quinine be given in a case of malignant tertian with congested liver, the quinine further depressing the action of the liver will aggravate matters and so precipitate an attack. I am quite agreed to accept the author's views as to the presence of an auto-lysin leading to the hæmoglobinuria, and I do not consider my view of black-water fever in any way militates against their observations. In my opinion owing to the biliary condition present there are circulating in the blood in such cases probably imperfectly formed varietes of bile pigment, and that such pigments in some way unexplained cause the clogging of the red corpuscles and their solution. That bile pigment in some form does circulate in the blood in such cases no one will deny who has any experience of the disease and there is urinary evidence of it.

There is one point I would like to point out in connection with black-water fever and that is a point in its treatment. In all cases it is of the utmost importance to primarily relieve the liver congestion before giving quinine. The prevention of black-water fever consists in the prevention of malignant tertian malaria and in relieving the liver of any congestion in such cases before the exhibition of quinine. With regard to *Cassia Beareana* I would like to add that I have found it most useful both in severe malignant tertian malaria and in black-water fever. But to be of any use it must be given in doses double that in which it is usually given. Two to four drachms three or four times a day, or one drachm doses every hour or two. I have found it to have in such doses a diaphoretic, diuretic and cardiac tonic effect. It seems to have an action similar to digitalis combined with a diaphoretic effect.

Dr. Powell said that some 10 to 12 years ago, he was the first to show that black-water fever consisted in malaria plus another factor that he called X. What was the X? He found that it was quinine sulphate, and that it was instrumental in causing hæmoglobinuria. Quinine bichloride was alleged not to act thus. But the condition predisposing to the deleterious action of the quinine, was congestion of the liver. In Bombay however where this condition was common black-water fever was not observed, and, among 500 cases, he had come across one case only in a German prostitute who had come from East Africa.

Dr. Surveyor said he had seen black-water fever in a Parsee who had returned from Uganda, and identified in his blood the presence of crescents of the malignant type. He thought that the fever was due to the pernicious type of infection. Urobilin had been found by him in the urine of malarial patients.

THE HUMAN FACTOR.

An Extension of our Knowledge regarding the Epidemiology of Malarial Disease.

BY

Capt. S. R. CHRISTOPHERS, M.B., I.M.S., and CHARLES A. BENTLEY, M.B., D.P.H., D.T.M.

It is usual now-a-days to consider that all facts in regard to the epidemiology of malaria are explained in full by the anopheles factor. It is thought sufficient to explain the outbreaks of malaria associated with excavations connected with railway and other works by the supposed formation, during the operations, of anopheles breeding places, outbreaks in connection with irrigation works as due entirely to the admission of water to places where previously anopheles could not breed in any number. With this idea, intensely malarious countries also are thought to be so by virtue of their special suitability for producing anopheles in large numbers or on account of the existence in them of species particularly susceptible to malaria and specially competent to transmit the disease. But if we investigate malaria carefully and in detail as it is seen under various conditions, we find it not always so easy to see the obvious relationship claimed; and we are forced to conclude that generalisations such as those we have instanced are for the most part unsupported by direct observation and that further investigation is required before we can explain a number of points in the epidemiology of malaria.

Speaking generally, the parasite being present, the amount of malaria is frequently proportionate to the number of anopheles, and this in turn bears a direct relation to the distance, number, and extent, of suitable breeding places. But there may be abundant anopheles and little fever, and much fever with few anopheles present; and both these conditions being frequently encountered they cannot be passed over as having no bearing on the subject of malarial epidemiology and the question of prophylaxis.

In regard to breeding places our own observations appear to show that, contrary to frequent statements to the reverse, the number, suitability and distance of these does not in many instances appreciably affect the number of anopheles, which seems in many cases to be largely determined by the food supply available. And usually where anopheles become abundant it is not only because of increased breeding facilities, but by reason of larger supplies of food and other conditions, associated with a population living in squalor in primitively constructed houses which afford suitable shelter for mosquitoes, as well as other circumstances favourable to the continued existence of the insect. Species of anopheles has an importance both direct and indirect, direct in that certain species seem either to be specially susceptible or insusceptible to malarial infection—thus M. Listonii and M. Funestus appear to be exceedingly susceptible while P. M. Rossi for some reason is not so,—and indirect in regard to powers of flight, habits, length of life, and a number of other points not yet determined. But an abundance of anopheles of a species competent to carry malaria is not necessarily accompanied by a special prevalence of the disease. In brief the Anopheles Factor does not altogether explain the absence, fluctuations and relative intensity of malaria, nor does it alone always afford a satisfactory reason for the occurrence of epidemics or the permanent exaltation of malaria characteristic of certain areas.

THE HUMAN FACTOR.

Non-immune Immigration.

Koch has described three types of villages in a malarious country, those with little or no malaria, those with malaria among children only, and others with extensive infection of the general population. On enquiry he found that this latter type of village invariably possessed a shifting population and was subject to the influx of susceptible newcomers, to which facts he ascribed the prevalence of the disease. A continual immigration similar to that described by Koch is conspicuously present in the Duars, Assam and elsewhere in India, and must play a considerable part in influencing malaria in these districts.

Low Social Status.

Stephens and Christophers, again, have observed a greater prevalence of malaria among low class communities than among those of better social status in the same locality. Celli, too, has shown that the prevalence of malaria in the Roman Campagna is closely bound up with the social and economic condition of the people.

Residual Infection.

A factor which appears to be scarcely less important than non-immune immigration is the effect of physiological poverty and hardship in maintaining a condition of residual infection.

Ross in computing the probable time during which infection may remain in the body, capable at any moment of being stimulated into activity by the action of any depressing influence, fixes the period as shown in British troops at about six months. In this case we are dealing with Europeans originally healthy picked men, well fed, well housed and under constant medical supervision. But if we conceive of natives often originally possessed of poor physique and little stamina living under conditions of depression, privations and hardship pushed to their extreme, it is obvious that these will form a soil far more suitable for the continued existence of malaria; and the problem becomes entirely different and one for the solution of which we have at present no data.

But experience seems to show that in a community composed of malaria-stricken subjects of this class, in a state of physiological poverty and exposed to hardship, infection diminishes very slowly even in the absence of anopheles; and the presence of even a very small number of anopheles appears to be quite sufficient to keep up the

maximum degree of parasitic infestation. This *factor of Residual Infection* may thus convert a whole community into a reservoir of infection, ever ready to involve its neighbourhood in epidemic sickness, and capable, on the migration of its members, of diffusing malarial infection far and wide.

Turning to conditions in the Duars we may state without going into detail that we found malaria extraordinarily prevalent and peculiarly intense throughout the whole area. But though the disastrous results were plainly evident, it was at first impossible to point to the particular factor to which the exaltation of endemicity was due. Geographical situation, at best a lame excuse, did not help us, for the adjoining Terai, which once held premier place for deadliness of climate, is now considered far less unhealthy, while parts of Assam with physical features and geographical situation almost identical, though by no means healthy, show nothing approaching the malariousness of the Duars. Though anopheles mosquitoes of a dangerous variety could be found throughout the district, their number bore little relation to the amount of malaria, and breeding places were so scanty in certain places, and existed for so short a period, as to render it difficult to understand the existence in these areas of even a moderate degree of malaria. On further consideration we realised that the Duars with its innumerable labour camps presented an example on a gigantic scale of the conditions that we have seen elsewhere in the tropics in connection with railway construction and similar enterprises, conditions that in our experience are practically always associated with the existence of malaria in its most intense form. For enquiry and reflection showed that it was possible to see, in circumstances like those before us, all the factors that we have previously described acting together in their full intensity, and in addition a strange system of vicious cycles holding sway and driving everything to one common end, namely, the extraordinary exaltation of malaria. We believe then that in this combination of all known factors favouring malaria together with the further action of certain vicious cycles induced by the presence of these factors, serving at once to multiply and extend the mischief, we have the explanation of the special and peculiar unhealthiness of the Duars. And herein, we think, lies the explanation of the facts which led to the old view ascribing to the soil itself the origin of an especially intense malaria so frequently encountered in the tropics in association with excavation and other works involving soil disturbance.

The Tropical Aggregation of Labour.

Labour in the tropics whether in India, Africa or elsewhere is usually of the kind known as "coolie labour" usually collected from far and wide and settled down in labour camps somewhere in the immediate neighbourhood of the scene of operations. Labour camps, which are more or less of a temporary nature, may contain some hundreds or even several thousand inhabitants, but they resemble neither village nor town, for the rude shelters and huts which form the vast majority of the dwellings are almost invariably of the most ramshackle description, while the density of the population on the camp site becomes as great or even greater than is met with in towns. Such aggregations also lack the sanitary arrangements, the permanent houses and the material comforts of abundant food supply and sufficiency of comparatively good water usually enjoyed by urban communities. In addition they are just the size and offer just the amount of aggregation most favourable for anopheles which can breed over a wide area around and about them. The coolie inhabitants are drawn from various localities, often from different provinces or perhaps distant countries; some come from malarious places, others from regions comparatively healthy; some are already infected with malaria, and others when they first arrive are free from infection and very susceptible. Thus month by month and year by year, if the operations extend over a long period, there is a constant admixture of infected and susceptible persons eminently suitable for the greatest exaltation of malarial infection.

Were these conditions to arise in the course of natural movements of mankind and in association with fair prosperity they might prove sufficiently disastrous, but in the conditions peculiar to labour camps we have introduced the other factors and the vicious cycles previously alluded to. Once sickness, debility and anæmia become rife the pressure and frequency of individual hardship becomes enormously increased. Pay cannot be earned by the sick, who may suffer actual starvation. Nor is it only the workers who suffer, for by the inability of partially or completely disabled labourers to earn their pay, their relatives and dependents are exposed to greater hardship and increasing liability to sickness; and the greater the number of sick the more intense becomes the general infection, until as a result an immunity that may protect under ordinary conditions is broken down under exposure to more virulent and intense malaria, so that even those originally the strongest and most healthy become involved also.

Again the more unhealthy a centre becomes the greater is the resulting loss of labour by death, sickness, desertion and migration, and this necessitates for the continuance of the work the introduction of new recruits at more frequent intervals and in larger number, providing a constant supply of fresh material for a still further extension of the mischief. Nor is it the immigration factor alone which becomes of increasing importance; for by the very nature of things, large numbers of the most destitute and needy are gathered together along with the miscellaneous crowd of workers; while hardship and privation tend to become more and more acute.

The orphan with no parents, the man with no wife to do his cooking, the mother without means to nourish her fatherless children, the stranger without friends, and those of poor physique or low intelligence, all suffer under such circumstances to a far greater extent than they would under ordinary rural or urban conditions. Prices of food are usually high; and there is nothing to maintain a proper relationship between the amount of pay actually received and the cost of an adequate diet: while a sum that in

ordinary circumstances would ensure plenty becomes under such conditions often insufficient to prevent hardship and privation. Native contractors and sirdars too in their endeavour to avoid loss, or to increase their gains, adopt, among the workers in their charge, systems of minimum living allowances and usurious advances. So hardship induces sickness and further hardship, while every case that goes under tends to swell the tide of suffering and increase the amount of infection. *It is this combination of factors and series of vicious cycles that is, we believe, responsible for the intensity attained by malaria wherever the undertaking of large projects in a malarious country involves the employment of numerous labourers and the establishment of labour camps.*

But the mischief does not end here. It will be gathered from what we have already said, that along our new railway line, throughout our canal zone, or scattered generally over an area devoted to an important industry requiring coolie labour, there will arise numerous foci of malaria in the form of labour camps. In the ordinary course of things small shops and markets spring up near the larger camps ; and villagers come in with supplies of food ; also numerous petty traders and others engaged in carting and carrying operations of all kinds move constantly backwards and forwards between the new scenes of industry and the old local trade centres. As a result many small villages and, if the undertaking be a large one, even towns, on the line of approach form recognised halting places, and become swollen and overcrowded by the influx of strangers. To these places come sick coolies from the works in progress, for nothing is so unsettling as sickness ; and as malaria increases in the labour camps many members of families that have been decimated by the disease endeavour to reach their homes under conditions of the greatest hardship.

As an example of what we have described, we cannot do better than quote from Major Leonard Rogers' Report on Kala-azar, a case used in another connection, but illustrating the very point under discussion.

"A coolie woman, aged 19, from the Assam-Bengal Railway (then undergoing construction) was admitted to the Nowgong dispensary during the rainy season of 1896, suffering from marked anæmia and dropsy of the feet and face. The history of her illness was that she got on all right until her father died (*vide* our remarks *re* decimated families) after which she lived with another coolie girl, and according to her history she only received about one rupee a month (*vide* our remarks *re* minimum living allowances) from the contractor, and was consequently unable to feed herself properly. She soon became ill, and as she did not improve she left the works and begged her way some forty miles into Nowgong, living on what she could pick up on the way."

Thus it happens from one cause and another that new centres of infection are set up in places even many miles removed from the original source of the mischief ; and once these have been established, the gangs of fresh labourers travelling to the scene of work, contract the infection as soon as they have entered the dangerous zone, and while they are still perhaps some distance from their destination ; and thus, by an unending train of vicious cycles once set in motion, there may result a widespread epidemic, perhaps far reaching and disastrous in exact proportion as its initial cause is extensive and important. And again those who return to their homes or seek new scenes of industry carry the infection of malaria wherever they go and if their number be at all considerable, and it must often be so, serve to disseminate the germs of malaria widely, wherever and whenever they are brought into relation with anopheles mosquitoes.

Involved secondarily in the general trouble are Europeans employed upon the enterprise and others dwelling in the vicinity, while few who visit it however briefly escape without contracting malaria ; and should the conditions last for sufficiently long a period, as they have done in the Duars and other places, we may hear of the occurrence among these people of cases of black-water fever. It often happens that the effect upon the actual labourers and native populations in the neighbourhood may pass unrecorded and unnoticed, the outbreaks of disease and death among Europeans alone attracting attention, as appears to have been the case during the Hong-Kong epidemic ; but there can be little doubt that were investigations to be undertaken in such cases, it would be found that the infection of troops and Europeans was but a concomitant of a vastly greater amount of malaria among the native population, especially the actual labourers concerned.

In the case of new railways we have then to deal not alone with the formation of borrow-pits and interference with surface drainage, but with a peculiar set of conditions, which are probably more or less identical throughout the tropics. In canal construction, too, we have other considerations to take into account beyond the mere formation of water channels, which, though they may undoubtedly assist in increasing malaria, are probably but an accessory cause of canal epidemics. We have labour communities engaged in the primary excavation of the main channel, the members of which are subsequently drafted off throughout the district for the purpose of cutting the distributing branches, and in addition the influx of immigrants seeking to secure land or to find employment in the newly irrigated area. All these points refer to a complex of factors that it is impossible to dismiss without serious thought if we wish to understand the natural history of great outbreaks of malaria. It is obvious that in the clearing of jungle, the making of roads, and all such operations as are required in the opening up of new countries, labour is necessary ; and one has only to visit a large road under construction in forest country, or a tea-garden being newly established, to realise that the malaria associated with such undertakings is merely the result of *Tropical Aggregation of Labour*.

But it must not be imagined that the conditions that we have described and the effects that we have indicated, as resulting from these conditions, are to be seen occurring on a small scale only, or confined within merely narrow areas, or that they are to be met with only occasionally in the course of years, constituting but an unimportant

item in the epidemiology of malaria. We have seen that in the case of the Duars the inauguration and extension of an industry has produced in that district an extraordinary condition of exalted malarial endemicity, characterised by black-water fever among Europeans and widespread anæmia among the natives, a condition perhaps well described in relation to the malaria of a population as one of "HYPER-ENDEMICITY." Under similar circumstances the Darjeeling terai attained some years ago an unenviable reputation of a like nature, and Assam, especially in past years before legislative interference enforced the adoption of certain sanitary precautions, was considered little less deadly for both native and European. In Mauritius, although there may have been a time when no suitable anopheles were present to transmit malaria, there appears to be present a typical example of *tropical labour aggregation*, and Dr. Bolton's description, given in Ross's Report upon Malaria in Mauritius, of the agglomeration of Indian huts scattered over the island, and the "camps" on the sugar plantations, illustrates very well the points we have alluded to. It is interesting to note also that Hirsch as far back as 1881 appears to connect the great malarial epidemic of Mauritius and Reunion in some way with the sudden expansion of the sugar industry and the laying out of many new plantations; while it is evident that railway construction and many building operations may have exerted a considerable influence upon the public health. We must remark also that while all this was going on, the immigration of coolies from Bengal and other parts of India was in full swing.

A possible example of the working, on a colossal scale, of the factors we have been describing is the series of vast epidemics of malaria that have ravaged Bengal during the last forty or fifty years, for the occurrence of which our hypothesis seems to offer the first satisfactory explanation.

THE HISTORY OF MALARIA IN BENGAL.

In a tropical country like India there is perhaps every *a priori* reason for expecting malaria to be both prevalent and intense; but if by such intensity we mean the condition so characteristic of the African Coast we shall have to modify our conception. There is indeed a considerable amount of evidence to show that large tracts of India are not particularly malarious in the sense that many other tropical countries are. Much of Bengal is deltaic in formation and we might expect that here especially malaria would be particularly intense; but our observations on the endemic index do not support this view, and, except in certain parts liable to great epidemics of malaria, this disease does not apparently prevent prosperity and a natural increase of the population. But since the fifties a tract in Bengal lying mainly to the north of Calcutta and comprising the districts of Jessore, Nadia, Burdwan, Hoogly and portion of Birbhum and the 24-Pargannas has been the site of recurring epidemics of fever which every few years have broken out first in one area and then in another. In 1860-63 fever broke out to an alarming extent in Jessore (pop. 1,577,249) and Nadia (pop. 2,017,847) and involved Barasat and the northern portion of the 24-Pargannas. In 1867 the great Burdwan epidemic occurred and swept through the district of that name, affecting parts of Birbhum and Midnapore also. This outbreak, which is calculated to have destroyed two millions of people, has been ascribed to kala-azar, but we have no evidence that this disease was concerned, and it appears probable that, whatever other diseases may have been present, malaria was in the main responsible. The census of 1881 records that in 1872 "the ravages of malaria at Dinajpore with a population in 1881 of 1,514,346 were greater than in any other district in the division," that "by 1877 things were still worse, until at least 75 per cent. of the inhabitants were in a bad state of health and 53 per cent. of them were suffering from enlarged spleen, while the recorded death-rate had reached 42 per mille." "In 1878-79 there was some slight remission, but in 1880 the condition returned with increased virulence." In Rungpur with a population in 1881 of 2,097,964 during the decade preceding 1880 "the district increased progressively in unhealthiness until 80 per cent. of the inhabitants were reported to be anæmic, suffering from enlarged spleen, or laid up with fever, and of the 20 per cent. supposed healthy only half could be considered so in the European sense." In Rajshahi with a population in 1881 of 1,338,638 and the neighbouring portions of Pabna immediately north of the Ganges is another area ravaged by frequent epidemics of fever about the year 1881; and further epidemics have occurred in various districts in 1893 and at later periods. Quite recently outbreaks have been recorded also from Birbhum and other parts of the Province.

Over and over again as the result of numberless enquiries it has been stated that the factor producing these epidemics has been a change in the natural drainage of the country. The theory that ascribes, to water-logging of the soil, the occurrence of such outbreaks is probably based on the old notions regarding malaria a little modified to fit in with our knowledge of the mosquito cycle of the parasite; but we have never heard of any investigation having proved an increase in the anopheles mosquitoes in the specially unhealthy tracts or during the epidemic years. In our opinion there is but one way, and that an indirect one, in which changes such as those in the great river channels may influence malarial incidence at all seriously, and this has been already pointed out by Chatterjee, who believes that the shifting of the great rivers towards the east, causing towns and districts once prosperous and flourishing to suffer from loss of trade, has produced, by the decay of industries and populations, an economic condition favourable to malaria. But though this has no doubt played its part, it does not explain why epidemics have specially prevailed during certain years over many districts, particularly in those places where industry, far from decaying, has been increasing.

Commission after commission of enquiry reporting upon the question has invariably dismissed the suggestion that roads or railways were concerned in causing obstruction to the drainage and that malarial epidemics could not be ascribed to their construction. Let us see how far the consideration of the human factors relating to the occurrence of malarial disease may serve to explain these conditions.

A glance at the map of Bengal will show that the districts that have from time to time been involved in the epidemic outbreaks of malaria bear a certain relation to Calcutta, and that they are practically coincident with the great industrial area to the north and west of that city and the expanding fan of railways that link the metropolis to the great districts on the north, north-east and north-west. Above all, the recurring epidemics have often picked out in a curious manner parts like the great coal districts of Burdwan, the mill district of Hoogly and other centres of industrial activity.

HOW FAR IS THIS A COINCIDENCE OR A REAL RELATIONSHIP ?

Before hazarding an opinion, let us consider the local history of this part of Bengal. Prior to 1860 there is little evidence of the existence in this area of anything like the modern movement towards the immense industrial expansion of recent times ; but from about this date commences a period of phenomenal activity and commercial enterprise and an era which saw the inauguration and completion of enormous public works. Within a decade three great canal systems, the great railways, a vast network of important roads, together with huge industries like that of coal, cotton, jute and tea, sprang into existence and underwent extraordinary development. Calcutta, the primary centre of this new movement, rapidly increased in size extending in every direction under the stimulus of a growing commercial activity, which necessitated the establishment of docks and the expansion of harbourage, and led to the erection of vast blocks of new buildings both within the city and throughout its widening suburbs. From 1868 onwards we find the Sone, Orissa, and Midnapore canals undergoing construction, 3-5ths of the whole scheme being completed by the year 1881. 1871 saw the completion in India of 2,800 miles of the first general scheme of railways linking up the most important towns and cities, Calcutta among them.

Between 1872 and 1881, 525 miles of railway were constructed in Bengal, and from 1881-91 a further 1,051 miles had been added to this total, still further increased by another 1,614 miles of open line by the year 1901. The coal industry too has undergone a wide expansion. The output which was small in 1840, had doubled in 1850, and quadrupled ten years later ; and by 1905 the Bengal coalfields alone contributed an output of 7,234,000 tons. The cotton and jute industries which in 1860 were in their infancy soon sprang into importance. Vast numbers of mills were erected all through Hoogly and the surrounding districts ; and by 1904 jute mills alone possessed nearly 20,000 looms and employed an average daily labour force of more than 130,000 people.

All this expansion has meant *labour*,—labour on the aggregate in vast amount,—labour brought together and employed under conditions little different and certainly no better than those to be seen at the present time, whenever and wherever projects of a similar nature to those we have been describing required to be carried out. Year after year now in this district, now in that, innumerable labour camps must have been formed. Along every new railway, every canal, every important road under construction, around every huge engineering work and building project, and in association with every rapidly developing industry there have arisen these more or less temporary aggregations of labour and these must have led to resulting outbreaks of malarial disease.

And if we follow as closely as possible the course of fever epidemics of Bengal and the years when they have especially prevailed we shall find that they correspond in an extraordinary manner with the times and places at which industrial projects and large public works were being most actively pushed forward. A special period characterised by the prevalence of epidemic malaria coincident with an expansion in the coal trade and the construction of great public works, may be recognised in 1860-74, and another in 1880-81 when after a time of lessened activity a number of important and long-postponed projects were put in hand and when it is recorded that the expenditure on railways, irrigation works, and roads alone had amounted to no less than twenty crores of rupees within five years.

As the presidency became opened up its railways extended, its canal projects brought in hands, its up-country industries developed, the series of malarial epidemics assumed a new phase. Reference to the Census Reports shows that there has been no more extensive emigration in India than that which has taken place from the western and southern parts of Bengal and portions of the adjoining provinces to the tea gardens in the north-east. The bulk of this emigration originally passed to Assam, but, with the extension of the tea industry in the Duars, large numbers of coolie labourers went northward in this direction. Until comparatively recent times vast multitudes of these emigrants travelled on foot to their destination or at least traversed in this way considerable tracts of country. A reference to the map shows that the districts of Dinajpore and Rungpur stand at the portals of the tea-districts and Rajshahi lies a little to the south. All the main lines of communication to the north and north-east pass through these areas which are covered with a network of roads and railways which have been steadily pushed forward especially in Rungpur and Dinajpore to meet the growing exigencies of the tea and jute industries. There are also other outbreaks of which the particulars are not yet before us, but of which we have reason to believe that adequate enquiry would establish the relation between them and causes not far different to those to which we have directed attention. The conditions of epidemic malaria thus briefly described cannot, in the absence of evidence and in the face of probability, be ascribed to changes in the drainage leading to an increase in the number and a widening of the distribution of anopheles mosquitoes ; we are forced to conclude, therefore, that the occurrence of epidemics of malaria has been due to the introduction of new factors, and it appears most probable that these have been the outcome of industrial expansion, acting in the manner we have indicated through the *Factor of Labour Aggregation.*

Time and further investigation must decide whether we have exaggerated the importance of this matter. If we

have not done so it seems clear to us that this new factor must be recognised and dealt with; for there appears to be every probability that when allowed to act year after year without attempt at control upon populations whose general health is already perhaps in a state of precarious stability, it may so far upset this equilibrium as to give rise to widespread outbreaks of fever and disease amongst them. The influence of floods and famines upon the public health is well recognised; but disasters of this kind though attended by outbreaks of disease in which malaria may sometimes be conspicuous do not, as evidence shows, necessarily give rise to epidemic malaria; and such causes have rarely exerted an appreciable effect in Bengal. Labour aggregation with all its attendant conditions appears in this province at least to supply the key to the riddle of epidemic malaria, in which it seems to have played a part far more important than movement of populations or general scarcity and want.

Industrial expansion in the tropics is but beginning, every year its requirements become more urgent, every year it is taking fresh strides, and, on the threshold of every advance, in India as well as in every other tropical country, we are met by the necessity for this industrial aggregation of labour. In the light of our present knowledge it appears probable that, in proportion, and as a natural sequence to the rise of a tropical country in importance in the sense understood by the civilised world, the conditions we have described will develop to an alarming extent and great tracts of country will be converted into regions of intense malaria with results both disastrous to life and ruinous to prosperity. At the present time a great expansion in coal and other industries is taking place in India. There is nothing to make us believe that deltaic or other physical conditions are necessary for the occurrence of outbreaks of malaria, for anopheles mosquitoes exist widespread throughout the country and can everywhere find facilities sufficient for their continuous breeding; and such being the case we have reason to believe that, with each fresh impetus and new direction given to industrial expansion, we shall find in the absence of proper measures of control an extension of the geographical distribution of intense malaria, and hear of new areas subjected to the ravages of epidemics. It may be said that these unfortunate influences, the action and results of which we have indicated in broad outline, are in themselves so vast that they lie beyond the power and scope of human interference and that their recognition will not help us in the fight against disease. But though we may not be able to deal with the malaria of a whole province, whose population numbers many millions, many of whom are probably but little affected by the disease, we can attempt to control the main foci of dissemination. We can deal with malaria among labourers on a railway, canal, coal-mine, or tea-garden in a way that we cannot do with malaria among the more scattered populations of great rural areas; and by this means we can prevent or reduce the occurrence of the otherwise inevitable scourge of exalted and intensified epidemic malaria, and attain an effect that will prove out of all proportion greater than the mere direct result to those immediately concerned: for we must reiterate that far beyond the loss of life and the misery of the actual labourers, is the all-important question of the health of a whole country-side.

As to the methods to be adopted we do not here concern ourselves; but if we are dealing with an exaltation of malaria due to the action of factors affecting the human host, where every influence that tends to increase susceptibility is at its height, there are besides the more specific preventive measures other reforms required. Hardship, exposure, bad housing, poor and insufficient food supply and impure water, the overcrowding of sites as well as the overcrowding of dwellings, all require attention and such control as to prevent or at least minimise their effect.

But to hope on the other hand for a direct result from anti-mosquito operations applied to any conditions than those of very special and important small localities seems entirely chimerical.

No anti-malarial campaign that has proved successful up to the present can be called strictly speaking a demonstration of the value of mosquito destruction alone, but represents the total effect of every available means at our disposal that may directly or indirectly diminish malaria, including the free use of quinine and improved sanitation. Moreover they have dealt with more or less insignificant populations, in some of the more vaunted instances with communities of people numbering no more than are to be found upon a single tea-garden. The cost, too, owing to the adoption of every form of anti-malarial work combined, has been extremely heavy, while, because of this also, such campaigns have failed totally to show the superiority of any single method or the relative value from the point of view of expense. It is impossible to argue from such cases the probable effect to be derived from large scale drainage operations, or measures directed against the mosquito alone; and we have already shown how small a relation mere number of anopheles often bears to the prevalence and intensity of malaria when conditions unfavourable to the human host are present in a marked degree. This being so it is impossible with our present knowledge to be certain that the inauguration of vast drainage schemes at a cost of crores of rupees will have the slightest appreciable effect in reducing malaria in Bengal and it is quite possible on the other hand, that, without the most careful control of the conditions relative to the labour employed on such work, grave danger may be incurred; and this very measure far from reducing malaria for a time at least will serve to actually increase and intensify it; while the larger the scheme the greater will be the danger from uncontrolled aggregation of the labour necessary for the performance of the work. As to the repeated statement that drainage of a country necessarily means a reduction in malaria by reducing anopheles mosquitoes, we may surmise, bearing in mind the Roman Campagna, and Celli's definitely expressed opinion, as well as our own experience in India, that the improvement following such work must often be largely secondary, and bound up to a great extent with the permanent settling of populations and other favourable conditions affecting the human host.

MALARIA IN MIAN MIR.

By Major S. P. JAMES, M.D. (Lond.), D.P.H., I.M.S.

It will be remembered by many members of this Congress that at the meeting of the British Medical Association held at Oxford in 1904 there was a discussion on the prophylaxis of malaria, the discussion being confined almost entirely to comments on the experimental anti-malarial measures initiated by the Royal Society's Commissioners and carried out under my direction and that of Captain Christophers in Mian Mir. Neither of us has ever thought it necessary to join issue with the critics whose comments were unfavourable on that occasion, and doubtless those who listen to this paper will be relieved to hear at once that I do not propose to do so now. I trust, however, that it will not be thought out of place if I say that at the meeting referred to, the absence of a history of anti-mosquito work led to criticisms being made either in entire forgetfulness of the state of knowledge at the time when the Mian Mir experiments were initiated or in complete ignorance of their object and scope. In order, if possible, to prevent similar misconceptions in future, I will begin my paper with an account of such portions of the history of our knowledge regarding anti-mosquito work as are relevant to the measures undertaken in Mian Mir.

In the first place I may say that those who are interested in the history of anti-mosquito operations will find that when the Mian Mir experiments were initiated, the state of knowledge regarding the practicability of exterminating Anopheline mosquitoes was as described in the final report of the Malaria Expedition to West Africa. This report was published in February 1900, and it appeared to afford complete confirmation of the views brought forward by Major Ronald Ross in the previous year at a lecture entitled "The possibility of extirpating malaria from certain localities by a new method." Without entering into details it is sufficient to say that the new method which Major Ross proposed consisted in carrying out such small works of surface drainage, obliteration of pools, and "petrolage" or "oiling" as could be accomplished by a few labourers banded together to form a body styled, later, a "Mosquito-brigade." It is important to note that this method was entirely different from the old method of reducing malaria by drainage of the soil, its chief advantages over that method being its extreme simplicity, its great cheapness, and the fact that it inconvenienced the general population of a place only very slightly, if at all. As regards its simplicity it may be noted that the members of the West African expedition thought that in order to have every puddle in Freetown oiled twice a week the services of only one man would be required and that they unanimously came to the conclusion that if the larvæ in the portion of Freetown which they examined were persistently destroyed or if the pools were entirely obliterated the insects might be very largely reduced if not almost exterminated in the area. The extent of the area appears to have been about one-eighth of a square mile.

The state of knowledge in 1900 may therefore be summarised thus:—It is probable that if in a place like Freetown all breeding places in an area of one-eighth of a square mile are obliterated—a work which it is believed can be accomplished by a mosquito-brigade—the prevalence of malarial fever and mosquitoes in the area will be very greatly reduced.

In that year and the next no one doubted, that if the method should prove to be only half as simple and cheap as appeared likely, it was the only right way of getting rid of malaria, and it was received with enthusiasm by administrators who, while being already aware (like the ancients) that large drainage and other engineering works reduce malaria and improve the public health generally, knew that such works on account of their expense could be carried out only very rarely in the tropics. The new method, however, while it promised to be applicable even in the poorest places, had not been tested by actual experiments, and Major Ross was foremost in urging their necessity before a final judgment upon its value could be given. Some time elapsed before he had an opportunity of testing it himself, but in July 1901 a campaign with this object was commenced under his direction at Freetown. Major Ross reported that this town was selected because it had been previously surveyed by the expeditions of the Liverpool School and of the Royal Society and because on account of the heavy rainfall (160 inches per annum), and the nature of the soil, it afforded a fair and, indeed, somewhat severe test of the feasibility of the new method which he recommended. The experiment was designed to be a model of the measures required for reducing mosquitoes and malaria by this method.

The necessity for a similar trial of the plan in India was now obvious, and, while arrangements for the Freetown experiment were in progress, the members of the Royal Society's Commission in India were searching for a cantonment in which such an experiment would be likely to be attended with success. They sought a place where the demonstration of the value of the new method would be complete. For reasons which it is not necessary to detail here, Mian Mir appeared to them to be an ideal place for an experiment of the kind and in October 1901 (that is three months after the beginning of the Freetown experiment) the campaign was commenced by a thorough malarial survey of this cantonment. The actual anti-mosquito operations were begun in April 1902 and, while being of the same nature as in the Freetown experiment, they were considerably more extensive and thorough than those undertaken in that town.

I think it will now be plain that the object and scope of the experiments at Mian Mir, as at Freetown, was to ascertain the value of such operations as are within the compass of mosquito-brigades, or, in other words, to ascertain the value of Major Ross's new method of extirpating malaria. It was never our intention to demonstrate the value of large drainage or other engi-

neering works, not only because such works were not contemplated in Major Ross's method, but because if we had demonstrated the value of such measures people would have said we had proved nothing new and nothing of advantage : " Even the ancients," they would have said, " knew that malaria can be reduced by large and expensive drainage works ; what we want to know about is the simple and cheap way of reducing malaria recommended by Major Ross."

It is now a matter of common knowledge that we were unable to demonstrate that Anopheline mosquitoes and malaria can be appreciably reduced by the new method in Mian Mir, and I believe I am right in saying that largely, as a result of our experiments and of those at Freetown, a great change occurred in the opinions and practice of nearly all advocates of mosquito reduction as a means of reducing malaria. The change to which I refer has not been emphasized by those who have written the history of anti-mosquito work but it will be evident if I place side by side the opinions which prevailed in the early years of this work and those which prevail at present.

Opinions in the early years.	*Present Opinions.*
The task of reducing Anopheline mosquitoes is very simple and exceedingly cheap. These are the great advantages of employing this method of reducing malaria. Financial considerations have frequently prohibited the employment of the old method of reducing malaria by drainage of the soil; they can scarcely prohibit the employment of the new method.	In malarious places like Freetown, Mian Mir, Panama, &c., the task is very difficult and expensive. In all operations much money must be spent, the amount being regarded by some authorities as a good test of success or failure in the operations.
The task can be accomplished by such works as are within the compass of mosquito brigades ; large drainage and other engineering works are not necessary.	Large drainage and other engineering works in connexion with water-supply, filling up or draining marshes and swamps, abolishing irrigation, restricting cultivation, paving roads, &c., are essential—a return to the methods of the ancients. Such work as can be accomplished by mosquito-brigades is entirely of subordinate value but is necessary in order to complete and keep permanent the good results effected by the above measures.
Efforts localized to such small areas as the immediate neighbourhood of particular groups of houses or barracks will be followed by a reduction of malaria in these houses or barracks.	In malarious places the results of measures localised to such small areas are inappreciable, however carefully the measures may be carried out.
It is easier to eradicate "Anopheline" than "Culex" mosquitoes.	It is easier to diminish the numbers of " Culex " and " Stegomyia " than of " Anophelines " but the complete eradication of any kind is impossible.

I think this remarkable change in opinion deserves to be chronicled on account of its importance to those who in any place are called upon to decide what measures for the reduction of malaria shall be employed. To those who are able to specify the really malarious localities in India it must be obvious that, as soon as the destruction of mosquitoes is admitted to be expensive, the measure at once becomes impossible of accomplishment in the very places where the reduction of malaria is most necessary ; financial considerations, as Major Ross has said, prohibit its employment.

The change in opinion and practice may be characterized as the second stage in the history of anti-mosquito work, and it was well exemplified in the case of the Mian Mir experiments when the military authorities decided that, the simple measures of the new method having failed, they would carry out large works of the kind already mentioned under the heading " Present Opinions." From the point of view of the scientific experimentalist, though in all probability not from that of the practical administrator, this decision must always redound greatly to the credit of the military authorities. The chief measures undertaken were (1) large works of surface drainage were carried out by the Royal Engineers and irrigation was completely abolished throughout the cantonment ; (2) with the abolition of irrigation every canal, ditch, and channel which had been used for that purpose was filled up permanently, and every pool and depression within half a mile of any house in the cantonment was also filled up, levelled, or drained ; (3) mosquito brigade measures were not discontinued when the experiments of Captain Christophers and myself were over, but were extended with great thoroughness throughout the cantonment. An interesting feature of the campaign was the employment of all the British and Native troops of the garrison (about 2,000 in number) on the work of filling in the canals and ditches. The limit of time allotted for papers at this Congress prevents my entering into details regarding the extent of the works, the thoroughness with which they were carried out, or the expense which they entailed. I would, however, ask all those who in 1904 criticised the operations of Captain Christophers and myself, on the ground that they were not carried out over a sufficiently wide area or with sufficient thoroughness, to accept my statement that such a criticism is no longer possible ; and, as regards expense, I would ask the critics who considered that sufficient money was not spent to accept my statement that despite the great amount of work done by the European and Native soldiers the experiment has resulted in the cantonment being at present (as I am

informed) "on the verge of bankruptcy". That the experiment has been effected at great sacrifice to every inhabitant of the cantonment, none who visits it can doubt, for the abolition of irrigation has naturally resulted in the almost total extinction of gardens, and I can well imagine that to those who have to spend a hot weather in this arid desert, life can have few, if any, joys. In experiments of this kind there is a danger that the restriction of cultivation and the compulsory abolition of nearly all vegetation will restrict the amenities of life to such an extent as to render the cantonment uninhabitable by man, and in all seriousness I would say that during a dry year the approach to such a condition in Mian Mir must be very close. Lieut.-Col. Rowan, R.A.M.C., in a most interesting paper on Mian Mir published in the Journal of the Royal Army Medical Corps for September 1908, gives some details of the anti-malarial operations and tells us that the work of filling in the canals and ditches in connexion with irrigation was finished in 1905.

This completes the account of such parts of the history of mosquito destruction work as are relevant to Mian Mir, and it only remains for me now to deal with the present prevalence of Anopheline mosquitoes and malaria in the cantonment, that is to attempt to appraise the results which have followed the experiments. The greater part of my material for this purpose was collected during a visit to the cantonment in October 1908.

I shall deal first with the prevalence of Anopheline mosquitoes. It will be remembered that the method upon which Captain Christophers and I relied for ascertaining whether there has been an increase or decrease in larvæ and adult insects depended upon the fact that, to an observer who is skilful in detecting these insects, and who has regularly collected them in specified places, a decrease or increase in these places must be obvious. This test still remains the best that has been employed in any anti-mosquito operations, the only other which has been used being what is called "the general consensus of opinion" which means, of course, the opinion of the irresponsible and untrained crowd.

I do not think the problem of whether there has occurred a diminution in the number of larvæ in the cantonment needs discussion, because it is certain that by the abolition of irrigation, the filling in of all pools and depressions, and the other works I have mentioned the number of breeding places has been enormously reduced. I did not see the condition of the cantonment during the rains of 1908, but at my visit in October, though I searched the most likely parts of the cantonment every day for four days, I could find only three breeding places, and only one of these—a borrow-pit situated at a distance of more than half a mile from the nearest house in the cantonment—was of considerable extent. I think there can be no doubt that, to quote an expression often used by Major Ross, the birth-rate of Anopheline mosquitoes in the area has been enormously reduced.

To the question whether there has been a marked reduction in the numbers of Anopheline adults I cannot give such a satisfactory answer. I can of course speak only of the prevalence of the adult insects at the time when I visited the cantonment in October 1908, and I propose to do so without attempting to surmise from whence the adult insects came. I searched for them in the British Infantry Bazaar, the Royal Artillery Bazaar, the saddle rooms of the Royal Artillery, and the houses of the 34th Pioneers. In all these places they were exceedingly numerous. In the three places first mentioned I attempted to form a rough estimate of their prevalence by ascertaining how many I could catch in test-tubes in a given time. The time was taken by the Hospital Assistant who accompanied me. After I had caught a mosquito and plugged the mouth of the tube with wool I handed the tube to him and he gave me another. In the British Infantry and Royal Artillery Bazaars, however, *Anopheles Rossi* were so common that I employed the test only for *Anopheles culicifacies*, a species which it is well known is difficult of detection. I found that from the ceiling rafters of one room in the British Infantry Bazaar I caught 12 *culicifacies* in 20 minutes one morning and eight in the same time from another room the next morning. In the Royal Artillery Bazaar I caught in one room 4 *culicifacies* in ten minutes, and in the saddle rooms 5 *culicifacies* and 12 *Rossi* in the same time. An idea of the prevalence of *Rossi* in the British Infantry and Royal Artillery Bazaars may be formed from my observation that in the darker parts of the ceilings of every room they were so thickly set as to be separated from one another by spaces of not more than one or two inches. In these bazaars also *A. fuliginosus* and *A. pulcherrimus* were fairly common.

On the whole I came to the conclusion that adult *A. culicifacies* and *A. Rossi* were somewhat more prevalent than in October 1901 and 1902.

I have to deal next with the prevalence of malaria under the headings of (1) its prevalence as shown by hospital statistics; (2) its prevalence as shown by an examination of the blood of soldiers in the cantonment; and (3) its prevalence as shown by an examination of native children in bazaars.

Whatever may be the opinion of those who are willing to believe that a simple statement of the admission-rates from malaria during periods before and after anti-mosquito operations have been conducted is sufficient proof of the success of the operations, I feel sure that every one in India is too well acquainted with the fallacies inevitable in such statistics to be content with such a miserable form of proof. And I feel sure also that if one can provide no other evidence than hospital statistics, these should be subjected to a very careful and detailed analysis before being regarded as of any value. In my office at Simla there are great facilities for an analysis of this nature and as regards the statistics of Mian Mir I have caused one to be made. Therefore, although I am aware that the statistics which I present here differ considerably from such statistics of the cantonment as have been published recently,

I ask you to accept my statement that they represent, as accurately as any statistics can do, the amount of sickness and death among European troops in Mian Mir during recent years.

Lahore Cantonment and Fort European Troops.

Years.	Annual sickness rates per 1,000 of average strength.							Death-rates.
	Enteric fever.	Malarial fevers.	Simple continued. fever.	Heat stroke.	Inflammation and congestion of the liver.	Anæmia and debility.	All causes excluding venereal diseases.	All causes excluding venereal diseases.
1904 ..	15·5	553·1	69·9	18·1	36·3	54·4	1183·9	14·25
1905 ..	26·1	52·1	335·3	36·7	21·3	48·6	1188·4	14·22
1906 ..	31·5	296·0	254·1	51·3	39·6	47·8	1185·3	15·15
1907 ..	19·0	135·7	103·8	4·0	28·9	26·9	600·8	10·98
1908* ..	13·8	576·6	126·9	5·0	8·8†	144·5‡	1275·1	16·33

Note—I have included the statistics of troops in Fort Lahore because it is garrisoned from the cantonment, with the result that the statistics appear somewhat more favourable than if I had dealt with those of the cantonment alone.

The table is sufficiently plain and beyond saying that the year 1907 was a remarkably healthy one for all troops in the Punjab, the total rainfall from June to December in Lahore being only 9 inches as compared with the average of 16 inches, I do not propose to discuss it. I am afraid even the most strenuous advocate of anti-mosquito operations could not infer from it either that the diseases which some years ago would have been diagnosed as malaria have been markedly reduced, or that the general health of troops in the station has been greatly improved.

While I believe that these statistics are the most accurate that can be obtained, it is necessary to point out that no official statistics regarding malarial fever represent at all accurately the true prevalence of the disease among troops. During October 1908 more than half the British soldiers in Mian Mir were either admitted into hospital or were being treated as out-patients for malarial fever alone, to say nothing of the admissions for "debility" the result of that disease; but even this statement represents very inadequately the havoc wrought by the epidemic. There are many British and Native soldiers who do not report that they are ill unless it is quite impossible for them to carry on their duties, and it is probable that among such men the proportion infected with malaria parasites is high, because "a touch of fever" is regarded very lightly by them. Owing to this practice of not reporting sick unless quite incapacitated, it often happens that the true condition of a regiment is not apparent unless the regiment is suddenly called upon to perform a march. This was well illustrated in the case of a native regiment which started to march from Mian Mir to Simla on October 3rd, 1908. The incidents of this march were very interesting from the point of view of the remarks I have just made, but I need not detail them here. The only accurate way of discovering such men—that is of discovering the true prevalence of malaria among soldiers—is to examine the blood of a large number. This is the plan which I have already mentioned as the second heading under which I proposed to deal with the prevalence of malaria in Mian Mir. I have not yet had time to examine all the slides of blood which I took for this purpose from soldiers stationed in Mian Mir during 1908 and in this paper I can give only the following observation. On the 27th of October I had an opportunity of seeing one of the "quinine parades" carried out. There were 42 men of the Gloucester regiment present at this parade and all of them were supposed to be healthy and all were doing their duty. As I was informed that all soldiers in Mian Mir were getting 10 grains of quinine twice weekly, the parades for this purpose being very thoroughly carried out, and that at the time of which I speak all men in the British regiment were getting, in addtion, a dose of "tonic mixture" daily, I did not think the results of taking specimens of blood from the men at this parade would compensate for the trouble involved. However, as I walked down the line of men I picked out ten, more or less at random, and afterwards took specimens of their blood. The following table shows the results obtained. I may mention that in the microscopic examination of these slides as well as in the examination of slides of blood from native children (the results of which I shall detail later) I adopted a time limit of five minutes for the actual examination of each slide. If during an examination lasting five minutes I could not find a parasite I recorded the result as negative.

* Statistics for 11 months only. † Inflammation only. ‡ Debility only.

Examination of Blood Specimens from apparently healthy British soldiers in Mian Mir.

1. Four malignant tertian rings (five minutes).
2. Three crescents (five minutes).
3. Four crescents (five minutes).
4. Negative (five minutes).
5. Two crescents (three minutes).
6. Numerous malignant tertian rings.
7. Many crescents and rings.
8. Negative (five minutes).
9. Numerous benign tertian parasites and many crescents (49 benign tertian parasites and 5 crescents counted at an examination lasting 2 minutes).
10. Negative (five minutes).

I think it will be acknowledged that in view of the facts that these men were supposed to be healthy (or at any rate that they were able to do their duty), and that they were getting 10 grains of quinine twice a week the results are very remarkable and indicate a very severe prevalence of infection among the European troops.

I have to deal lastly with the prevalence of malaria as shown by the examination of native children in bazaars. In my first report on the anti-malarial operations in Mian Mir a number of results were given which had been obtained in October 1901 for the purposes of this test by Dr. J. W. W. Stephens, Captain S. R. Christophers and myself in our prelimin-

ary survey of Mian Mir Cantonment. I reproduce here the figures which are of importance to us at present :—

Locality.	Time of year.	Percentage of children infected with malaria parasites (endemic index).	Per cent. with enlarged spleens (splenic index).	Number examined.
British Infantry Bazaar.	October 1901.	52	80	25
Royal Artillery Bazaar.	"	35	75	28
Native Cavalry Lines ..	"	24	36	25
Syce Lines—A ...	Nov. 1901 ...	56	48	25
Do. —B	"	20	20	25

For the whole Cantonment the actual numbers and percentages worked out as follows :—

Date.	Number of children examined.	Number infected with malaria parasites.	Number with enlarged spleens.	Endemic index.	Splenic index.
Oct. & Nov. 1901 ..	128	48	67	37·5	52·3

These figures are of permanent value because it must be obvious to all that if anyone eventually succeeds in extirpating, or materially reducing, malaria in Mian Mir, such a result will be evident by a great reduction in the figures. It may be said also that until a marked and permanent reduction in the figures occurs no one is entitled to say (whatever hospital statistics may appear to show) that he has materially improved the malarious nature of the Cantonment. Anti-mosquito operations have now been carried on continuously in Mian Mir for more than six years, during more than three of which irrigation has been entirely abolished ; and one was entitled to expect that by this time, if the operations had been successful, the figures would have fallen almost, if not quite, to zero.

No serious objection has been, or can be, urged against the value of this test as a means of proving whether anti-malarial operations have been successful or not, and it was therefore natural that, when I visited Mian Mir with the object of confirming, if possible, the favourable accounts which had been published regarding the success of anti-mosquito operations in that Cantonment, I should turn to it first.

Before stating the results of my work I must mention, on the authority of Lieut.-Col. Rowan, that for the last three years it has been the practice to give quinine twice weekly not only to all troops and followers but also to their families and to the children in the Bazaars; and that during my visit I found that a hospital assistant was on duty solely for the purpose of administering quinine to children in the British Infantry and Sudder Bazaars. In the lines of native regiments the quinine was administered to the children by the Hospital Assistants attached to the different regiments. I have no knowledge of the thoroughness with which the measure was carried out generally, but I must say that, being aware of the arrangements and having on one occasion seen the children in the Native Cavalry lines receive their doses, I was surprised to find so many children heavily infected with malaria parasites.

The following table shows the results of my work. In the actual microscopic examination of the slides I adopted a time limit of, as near as possible, five minutes, which, I think, is somewhat less than the length of time we were accustomed to devote to each slide in 1901. In attempting to gauge the value of the operations in Mian Mir I think I was justified in adopting a short-time limit, because by doing so one's results show the minimum rather than the maximum percentage of infection.

Results of examinations of native children in Mian Mir in October 1908 :—

Locality.	Date of taking slides.	Number of children examined.	Parasite rate per cent. (Endemic index)	Spleen rate per cent. (Splenic index).
British Infy.Bazaar	Oct. 25th, 1908.	For parasites 28 For spleens 25	68	64
Royal Arty.Bazaar.	Oct.26th,1908	36	78	Not examined for spleens.
Hospital and Syce Line Followers of Royal Arty. ..	Oct.27th,1908	14	80	85
Native Cavy.Lines.	Oct. 28th, 1908.	For parasites 25 For spleens 20	85	55
Native Infy. Lines (Dogras)... ...	Oct. 28th, 1908.	For parasites 20 For spleens 27	95	79
Native Infy. Lines (Pioneers) ...	Oct. 28th, 1908	For parasites 24 For spleens 27	83	74
Hospital Followers of British Infy. ...	Oct.30th,1908	36	Not examined for parasites.	64*

The Bazaars in which these children live are situated in all parts of the Cantonment, so that by combining the results we can ascertain with some certainty the endemic index and splenic index prevailing in Mian Mir in October 1908.

The following table contains this information :—

Locality.	Date.	Number of children examined.	Number with parasites in their blood.	Number with enlarged spleens.	Endemic index.	Splenic index.
Mian Mir.	Oct. 08.	For parasites 147. For spleens 141.	118	97	80·2	69

We are now in a position to enter in the following tables all the information that we possess regarding parasite and spleen rates in Mian Mir since anti-malarial operations were begun in that Cantonment.

* Kindly communicated by Lieut.-Col. Rowan, R.A.M.C.

I.—*Mian Mir as a whole.*

——	Oct.-Nov. 1901.	October 1908.
Parasite rate per cent. (endemic index)...	37·5	80
Spleen rate per cent. (splenic index)	52	69
Number examined ...	For parasites 128 For spleens 128	For parasites 147 For spleens 141

II.—*Specified localities in Mian Mir.*

——		Oct. 1901.	Oct. 1902.	Oct. 1903.	Oct. 1908.
British Infy. Bazaar	Endemic index.	52	41	...	68
	Splenic index .	80	69	77·5	64
Royal Arty. Bazaar	Endemic index.	35	20	...	78
	Splenic index .	75	64	64·5	...
Royal Arty. Hospital Followers and Syce Lines.	Endemic index.	56	...	...	80
	Splenic index .	48	...	60	85
Native Cavy. Lines.	Endemic index	25	...	...	85
	Splenic index .	36	...	...	55
Native Infy. Lines (Dogras).	Endemic index.	...	...	...	95
	Splenic index .	...	...	...	79
Native Infy. Lines (Pioneers).	Endemic index.	...	...	...	83
	Splenic index .	...	...	...	74

It appears to me that from whatever standpoint these figures are regarded the answer is as unequivocal as it is disappointing. I had hoped that it might at least have been possible to say that the anti-mosquito operations had mitigated though they had not prevented the epidemic, but if we consider for a moment that, although, many of the children whose blood was examined had undoubtedly been taking quinine at least once a week, parasites were present in the blood of from 68 to 95 per cent., we must conclude that the difference between a prevalence of this degree and one which is worse is inappreciable. In this opinion I feel sure I shall be supported by Medical Officers at Mian Mir who were able to observe the terrible havoc wrought by the disease among troops and followers in the Cantonment.

The lessons to be learned from the Mian Mir experiments are extremely important from the point of view of the military authorities and from that of administrators in general ; but, since in the present paper any remarks on this subject would have to be presented in a form that might, on account of its brevity, seem dogmatic, I do not intend to refer to them here. I will say, however, that after our operations of 1901 to 1903 were concluded, both Captain Christophers and I had hoped to obtain from those well qualified to judge some valuable constructive, rather than destructive, criticism ; and that we obtained none of the former but much of the latter. If it had been otherwise I can scarcely suppose that the military authorities (who aimed of course at the prevention of malaria among the troops only) would have carried out a system which has not only proved ineffective for the purpose they had in view, but has resulted in reconverting the Cantonment into the arid desert which it was fifty years ago.

I have tried in this paper to avoid reference to many more or less trivial criticisms which were passed upon the results of our operations of 1901 to 1903, but I think it is right that I should refer to the view that the results of our operations tended to arrest enthusiasm in the great cause of the prevention of malaria. In regard to this view I will only say that anti-malarial measures and mosquito-destruction measures are not, and have never been, synonymous terms except to those who regard the latter as the only method of value for reducing malaria ; and that, in my opinion, enthusiasm in the anti-malarial cause is not arrested by the somewhat rare instances when the truth regarding failure in mosquito-destruction operations has been proclaimed, but by the more frequent ones when success in such operations has been reported on evidence that will not bear criticism and is often ridiculous.

In conclusion, I desire to say that the fact that I have mentioned Major Ronald Ross only in connexion with expressions of apparent dissent from his views makes me wish the more to own that had it not been for his genius, enthusiasm, and strength of purpose, there might never have come within our view the attractive pathways of science which some of us are now endeavouring to explore.

DISCUSSION.

Surgeon-General H. Hamilton, C.B.,M.D.,I.M.S., said—Before asking for any criticisms on this paper I would like to say a few words myself as I know something about Mian Mir In fact I believe it was due to my advocacy that the canal there was closed. But the closing of the canal was not the only measure I advocated. I also advocated the introduction of efficient drainage. Major James states that this was done, but that is not so The existing cutcha channels were levelled and cleared and that is all. When I tell you that the drainage of Mian Mir runs either North or due West into the Ravi, the general fall of the country being from North to South, you will understand how inadequate the present drainage is. Until an efficient system of drainage is introduced Mian Mir will not be a thoroughly healthy station especially in years like this under discussion, when the rainfall was 33 inches instead of a normal of 21, or more than 50 per cent. above the average. Major James states that the station was quite dry when he was there in October, and that he only found three breeding places of anopheles. He seems to have inferred from this that the place had been equally dry all through the hot weather. As I said in my opening address I was informed at a visit I paid that on several occasions all the ground in front of the artillery barracks had been covered deeply with water for days together. Major James himself has pointed out that even when water of this sort disappears larvæ can live in the wet mud till the next rainfall. If it is a fact that there were more adult anopheles last autumn than in 1902, that would merely mean that there had been more water lying about from rain alone than there had been all the previous years from rain and canal combined. This is quite conceivable when you remember that a solid foot more water had fallen as rain and that there is no means of draining this off. But, in spite of this, the condition is infinitely better than if the canal with its innumerable irrigation cuts about three feet below the surface had still remained forming a regular net work of reservoirs for water—comfortable breeding places for anopheles. During some of the worst years in the irrigation period, the admission rate for all fevers amounted to well over 3,000 per 10,000 and I feel certain that the results last year will not be a fourth or fifth

of that. If so much has been gained, surely it was well worth closing the canal, for it is legitimate to suppose that last year with its exceptional rainfall would have equalled the worst known. At my visit to Mian Mir I found certainly a great deal of very severe malaria among the gunners, but there had been really very little among the native cavalry, and I was told there had been only three admissions among Officers. Major James says that in a short time owing to the impossibility of making gardens the place will become an arid desert and will be uninhabitable, but I did not find this gloomy view shared by the people in Mian Mir. I stopped with Lieut.-Colonel and Mrs. Ker who had not been able to get a house in Mian Mir the previous year and had been obliged to live in over-irrigated over-gardened Lahore, and they were congratulating themselves the whole time I was there on having a house now in Mian Mir instead of Lahore, and said their children did splendidly in the dry bracing cold. One of the most favourite stations in the Punjab is Campbellpore in which there is not a tree and hardly a green thing of any kind, so that the popularity of a place does not altogether depend on its trees and gardens.

Major James says he has included the statistics of Fort Lahore and therefore the statistics of the Cantonment may be too favourable, but Fort Lahore is about the most poisonous hole in India. On the melting of the snows the Ravi comes down in flood and floods the whole of the ground round the Fort and when it recedes, leaves regular swamps—lagoons—that it is impossible to deal with. When advocating the improving of Mian Mir I stated that it could never be a healthy station so long as it continued to send detachments to Fort Lahore to be infected there. Fort Lahore ought to be retained as a show place under a Police guard.

I would like to show what the natives think of Mian Mir now. An Officer, who is on the staff in another Division, came to Pindi last year, and in conversation with some of the native Officers of the 36th Sikhs to which Regiment he belongs, he said to them : I suppose when you leave Pindi you would like to go to Ferozepore or Jallunder or some nice little station like that, and they at once said, no saheb, we would like to go to Mian Mir because since the canal was closed there is no fever there and it is near our homes.

I think I have answered most of the points in Major James' paper. I think I have shown that so far from taking a gloomy pessimistic view, we should be well satisfied with what has been accomplished and encouraged to make further efforts. I confess it is amazing to me to find a man like Major James, who has done good work in connection with malaria and who has deservedly earned the reputation of having expert knowledge on the subject, standing forth as the champion of irrigation in cantonments or which is the same thing, trying to prove its abolition has only made matters worst. I well remember, when I was fighting hard to get the canal closed, Major James writing to me and saying that it would be useless and that the malaria would be as bad as ever and I am sorry to find that he still thinks so in spite of many facts that seem to me to prove the exact opposite.

Note.—

On quitting the section I met a Sergeant of the Gloucestershire Regiment that has just arrived in Bombay from Mian Mir and had the following conversation with him :—You had just come from Mian Mir ? Yes. How has your regiment been there ? We had a good deal of enteric. Had you any malaria? Yes, we had a great deal of malaria. Did it rain last year in Mian Mir ? It did nothing but rain. Did water lie about ? It was up to the third step of the barracks and lay all round the barracks. Did it soon run off ? No. What was the cause of the fever ? Water. Were there many mosquitoes ? There were myriads of them.

I then went to the Colonel of the regiment and told him that a paper had been read at the Congress to prove that the closing of the canal and the stopping of irrigation had only made matters worse. He was quite indignant at this, and told me that the year before in Mian Mir his regiment had been perhaps the healthiest in India, but that last year was very exceptional, and that Mian Mir was not nearly as bad as the stations round about Amritsar, Ferozepore, &c. He said that when he was down for a few days in August, he had to go from his house to the Mess on bricks put down as stepping stones. I next met a Major of the regiment and he told me that Major James's statements were not borne out by facts. It seems to be strange to say the least of it that these officers should "stick up" for Mian Mir if it were nearly as bad as Major James has painted it. I afterwards wrote to one of the officers who had been the whole time in Mian Mir and he wrote to me that "the rains began about the beginning of July and ended about the middle of September, and were very severe. Especially in August and September the whole country was waterlogged and water lay about in sheets." "The drains were always full." "On the Brigade Parade Ground there were places that never got dry." "Some of the compounds of the bungalows were regular lakes which dried up very slowly." These are facts that Major James could easily have informed himself at his visit to Mian Mir and it seems a very extraordinary thing that he did not do so.

Now as to his figures : he takes ONE year before the closing of the canal and compares the 4 years after the closing of the canal with that one year which happened to be a fairly healthy year, and because no great improvement over that *one* exists comes to the conclusion that no improvement was effected. His figures for the 4 years show an admission rate for all causes excluding general diseases of 1,188·4, 1,185·3, 600·8 and 1,275·1. If we take 4 years in the middle of the irrigation period we get admission rates *for fevers alone* for the years 1876, 1877, 1878 and 1879 of 1,545, 1,519, 2,667 and 3,416. Major James would hardly contend that 1,275 for all causes except venereal diseases was worse than 3,416 for fevers alone. It would in fact be hard to get an admission rate as low as 1,275 during the irrigation period which means that an exceptionally unhealthy year after the closing of the canal compares with an exceptionally healthy year during the time it was running.

Because Major James heard that the Cantonment was "on the verge of bankruptcy" he inferred, and means the Congress to infer, that the Cantonment funds were expended in closing the canal. Every Catonment is practically "on the verge of bankruptcy" in the sense that it lives from hand to mouth, and if anything untoward happens may be in the greatest financial difficulties. But not one penny of Cantonment funds was expended in Mian Mir in the improvements under discussion.

Professor Musgrave said that the Government of the United States was engaged in conducting an anti-malarial campaign in Panama, Atlantic City, New Orleans and in the Phillipines. The measures which Major James appeared to condemn, had answered well at those places. He had enjoyed Prof. Ross' paper and he must admit that there existed very few scientific men like him who would solve problems in the laboratory and also effect practical measures as public sanitarians. The gist of Major James' paper appeared to him to mean that all anti-malarial measures had failed. But all observers fully knew that, in order to have adult mosquitoes, the larvæ must be present, and larvæ could be found only in their appropriate breeding places. The results at Mian Mir were not in accord with what had been noted at Panama, where the reduction in malaria had gone down to 21 from 143. In his opinion, wherever anti-malarial measures had been properly carried out, Malaria had been always prevented, and, if they appeared to have failed at Mian Mir, it meant that water was present somewhere where it should not have been.

Capt. Christophers said that they knew from Panama that they could control malaria, but what they wanted to know was the comparative importance of the two chief methods of anti-malarial sanitation, *i.e.*, drainage and quinine prophylaxis. Anti-larval operations evidently were not the correct method to have adopted in Mian Mir where after all the number of persons to be protected was small and the area large. Looking back and considering the facts brought forward by Major James one can see that, instead of extensive anti-larval operations, attention

should have been mainly directed to pushing and perfecting quinine prophylaxis.

To use all methods of anti-malarial sanitation was obviously very commendable, but in practice a great deal depended upon whether one looked upon anti-larval operations as the chief weapon and quinine prophylaxis an auxilliary one or *vice versa.*

Attention being so much confined to anti-larval operations had hindered in India a proper amount of attention being given to quinine propaganda, which was really more suitable for general application to India. The Italians who had conditions to deal with like those in India, *i.e.*, a population mainly rural, had practically abandoned anti-larval operations in favour of quinine prophylaxis. Prophylaxis of malaria in India presented many problems. All India, for example, was not equally malarious, quinine propaganda in those rural areas which were being decimated by the disease was the most urgent measure called for. Everything pointed to the necessity of organisation such as had been used with such success by the Italians

Dr. Bentley said that he was glad that Major James' paper had emphasized the fact that the original operations at Mian Mir had for their object the testing of anti-larval measures.

In instances where every form of anti-malarial work was used in combination it was impossible to decide as to the relative value of different measures.

Mian Mir had demonstrated the futility of anti-larval operations.

What we wanted in India was further experiment to show the value of quinine prophylaxis among the general population. Jail statistics indicated its value among special communities, but in India no work had as yet been carried out on lines similar to the methods employed in Italy.

No speaker had alluded to the Italian anti-malarial campaign, but this work was specially instructive as pointing to the solution of the problem of the mitigation of malaria in Italy. The work in Italy was being carried out on a far larger scale than any other anti-malarial campaign in the world ; the cost was low ; and the results compared favourably with those that had been achieved at Panama, Ismailia, Klang and Port Swettenham, where the relative cost per head of the population dealt with was far greater. In every one of these instances quinine prophylaxis had been largely depended on, as reference to the full reports by *those actually engaged in carrying out the work* would show. It was very doubtful if any appreciable results would have been attained in any instance without the free use of quinine.

Professor Musgrave had criticised the work at Mian Mir on the grounds that in view of the success attained at Panama by the Americans, it was obvious that there must have been some fault in the work at Mian Mir. This criticism was beside the mark. The success of the work at Panama was of no use in helping us to decide as to what measures were applicable to India.

At Panama the total medical and sanitary expenditure amounted to £ 10 per head of the population per annum, and it was no wonder that such work was fruitful of results.

Any nation that could afford and was prepared to spend such an enormous sum would attain results as strikingly successful, but in India we could not spend a hundredth part of this per head of the population and the question still to be faced was the finding of a method of mitigating malaria sufficiently cheap to be generally available, and one that would at the same time prove effective. Quinine appeared to be the only means fulfilling these requirements.

Drainage operations were suggested in some quarters, but he would like to point out that at the present time we were absolutely ignorant as to the effect of drainage operations upon malaria.

He was aware that many people ascribed a mitigation of malaria to drainage, but the question had never been examined critically.

What were we to think when we were told that malaria was intense in one district because of extensive floods, and that in another and perhaps a neighbouring district, the annual flooding of the country rendered the place healthy by diminishing malaria.

Again we might learn of districts where epidemic malaria was associated with excessive rainfall and others in which deficient rainfall adduced as the cause of serious outbreaks of the disease.

Those who advocated drainage as a certain means of reducing malaria appeared to forget that the prevalence of the disease often bore no relation to the number of anopheles mosquitoes but depended largely upon other factors.

This point had been brought forward in the paper on the "Human Factor" prepared by Captain Christophers and himself and read by the former that morning.

Therefore until we had some definite knowledge regarding the result of drainage operations, it was useless to recommend such work except as an experiment, and this being so, the only logical course at present was to push the use of quinine, the value of which was certain.

In conclusion Dr. Bentley pointed out that, at Ismailia, during the successful anti-malarial campaign there, very large amounts of quinine had been used prophylactically ; and for several years an expenditure *upon quinine prophylaxis* equivalent to francs two per head of the population formed one of the most important items in the anti malarial work. This alone was sufficient to assure a great measure of success. Could we use a similar amount in India (equal to Rs. 1/4 per head of the population) upon quinine prophylaxis and treatment, we should produce after two or three years a tremendous mitigation of malaria throughout the country.

Lt.-Colonel Buchanan said there are two points regarding which I wish to make a few remarks. First on the question as to whether mosquitoes convey malaria, and second on the variation in the intensity of malaria from year to year.

I see present a large number of those who attended the Malaria Conference at Nagpur in 1902, and many will remember that on the last day of that Conference there was a case of Benign Tertian fever in which many parasites were throwing out flagella. Several groups of mosquitoes were fed on that case, and, a few days later, an old Hospital Assistant, who had previously doubted whether malaria is transferred by mosquitoes, said if we could give him fever he would believe. The mosquitoes were allowed to feed on him and he was told that he would get fever about a certain date. The old Burman (Ko Tha Aung) dissected any mosquitoes that happened to die and said that there was no doubt that the Hospital Assistant would be infected. The Hospital Assistant got fever for four successive days ; the parasites were similar to those which were found in the original case : they were examined by the Royal Society's Commissioners, and this case is probably the most complete case to prove the truth of Ross's great discovery.

In my Annual Reports of the past two years, I have made references to what I have spoken of as the variation in intensity of malaria in the same place in different years. For example at Ellichpur, where Liston began to study mosquitoes, there were a few years ago 12,000 cases treated for malaria but last year the number fell to a little over a thousand. A similar fall has been noticed at several other dispensaries, and it is very curious that, while malaria has been remarkably prevalent in the Punjab and in Bombay, there has been during the past year a remarkable immunity from malaria in Berar which lies between the Punjab and Bombay. This question of variation in intensity from year to year is one to which very little attention has hitherto been given, but it is one to which full consideration should be given before we can draw any reliable conclusions as to the effect produced by any anti-mosquito operations.

Dr. Surveyor said that, with reference to the remarks that fell from Surgeon-General Hamilton about the immunity enjoyed by European officers, it should be remembered that they invariably slept under mosquito curtains. In 1906, he himself was malaria free, as he was abroad; but on return to Bombay he developed malaria, and treated himself with 10 grains of quinine daily, but to no purpose, as the fever persisted and malignant tertian parasites were found in his blood. He took to sleeping

under mosquito curtains, and was soon freed. The latter was the only prophylactic in his case. His opinion was that mosquitoes should be left alone, but that the human host should be treated with quinine prophylaxis.

Major Rogers said the results of the Mian Mir anti-malarial measures described by Major S. P. James are certainly extremely disappointing, but I think there are some reasons for regarding them as less serious than at first sight appears. In the first place, Surgeon-General Hamilton has told us that owing to the rainfall in 1908 having been half as much again as the normal at Mian Mir, parts of the cantonment were under water for considerable periods, so that the adult anopheles found by Major James were doubtless bred in the cantonment at that time. Secondly, during the three previous years, a steady fall in the malarial incidence followed the closing of the canals, so that a further series of normal years are necessary before the full effects of the measures can be gauged, and the recent year of epidemic prevalence all over the North-west of India is hardly a fair test. Nevertheless, it is quite apparent that the prevention of malaria by anti-mosquito operations is extremely difficult in India, as I pointed out with regard to Bengal several years ago, while I have always maintained that far better results in proportion to the cost in reducing the death-rate from malaria in India may be obtained by the freer distribution of quinine, especially among the children, whose mortality is highest from malaria, and who can be largely reached, as I suggested in my Dinajpur report, through the agency of the village school-master. At the Nagpur Malarial Conference at Christmas 1960 a resolution proposed by me was adopted recommending malarial inquiries in every province of India, as the local conditions vary so widely that different measures are likely to prove most useful in different places. The present discussion indicated the necessity of further work in the same direction, and as such inquiries are now being carried out in Bengal, the United Provinces, the Punjab and Bombay, our knowledge of the best practical methods of fighting this great scourge in India should soon be available.

Professor Ross said that, at Havana, it was not quinine but an anti-mosquito campaign that had driven out malaria, and so also, at Ismailia, and, in the Malay States, drainage, and not quinine was the principal factor. He considered that anti-mosquito measures were the most important, although all other measures were not to be neglected. Success, in Panama, was due to the same measures. Towns and villages must, however, be differently dealt with. In the former drainage was essential, but in rural areas, drainage would benefit the animals only and hence quinine prophylaxis should be the principal measure. If Major James' conclusions were sound he would burn all his reports and books, but he thought that they left much to be desired, and if accepted would put back the hand of time, and for ever deter Government from adopting anti-malarial measures. He thought that all the contributing data had not been fully explained by Major James, they did not seem to him to be accurate and the measures adopted could not have been thorough, for if all sources of larval propagation had been destroyed, where did the adult mosquitoes come from? The statistics of children examined were too few, and no means for counting the number of mosquitoes were adopted such as Lefroy's cage. He wondered why Major James had not desired a better method of estimating the number of mosquitoes, and hoped that he would supplement the data furnished, which were incomplete. He was in favour of adopting *all* measures for the prevention of malaria.

Professor Ross asked a number of questions to Major James about the details of the epidemic of malaria at Mian Mir in 1908, laying particular stress upon the fact whether the troops as also the native children infected were permanently resident in Mian Mir. The replies elicited from Major James were not considered by him to be complete or satisfactory.

Dr. Arthur Powell thought the results at Mian Mir were by no means so gloomy as Major James had painted them.

For instance, take Major James' own figures showing the number of admissions to Hospital for malaria. (Major James objected that Hospital statistics were unreliable as too dependent on personal equations). Dr. Powell thought the personal equation loomed much larger in statistics of the "Splenic Index" which Major James preferred—compound personal equations depending on the patient as well as the examiner. He had known clinicians who claimed the *tactus eruditus* to the extent of palpating the normal spleen. How often at a consultation do we find the consultants divided as to whether the spleen can be felt or not? The good humour of the child examined was another factor in the equation. In obtaining the "Splenic Index" it was usual for a medical officer to go round the lines examining as many children as possible. If the children were in good humour, with flaccid belly-walls the spleen could easily be felt when but slightly enlarged. Given a bad tempered or frightened brat who howls the moment he is touched, it is impossible to feel even a large spleen through the rigid abdomen.

No. There is less personal equation in the Hospital statistics, and I ask you to look at those Major James has given us.

In 1904, there were 553 admissions per thousand, in 1905, after a year's campaign against the mosquito, the number fell to 52—*less than one-tenth* of the former year! Surely not a bad result—a reduction by more than 90 per cent. of the disease specially aimed at!

Next year, 1906, the admissions rose to 296, but still we have a reduction of about 45 per cent. on the admissions before the mosquito campaign began.

Next year, 1907, the cases fell to 135 *less than a quarter of the number before the mosquito campaign.* Last year, 1908, the malaria cases rose to 576*, a small increase of about 4 per cent. on the figures of 1904. Last year it must be remembered was a phenomenally bad year for malaria particularly in the Panjab. I myself have a force of some 2,400 sepoys and officers in my charge, among them the admissions for malaria were more than trebled last year, the most unhealthy year in Bombay as regards malaria recorded since any statistics approaching reliability have been kept.

I think the explanation of the swing of the figures at Mian Mir is easily explained. Apart from last year, which was a phenomenally bad one for malaria and also for rainfall, in which it was as futile for the troops to try to sweep the water out of Mian Mir as it would have been for the Bombay sepoys to have tried to sweep back the tide from Back Bay, there is the old adage that "new brooms sweep clean."

The mosquito brigades of Mian Mir were new brooms in 1905. They did their work so efficiently that the cases of Malaria in Hospital were only one-tenth the number of the previous year. Possibly they became slack in the following year, looking on the campaign as a mere fad. It is the way with most things human.

Major James replied to a number of questions put to him by Major Ross and referred to the criticism that the results of blood examinations were based on very small numbers. He said that Poisson's formula for ascertaining the limits of error is a quite inaccurate test except when applied to the ideal case of games of chance, and that its application in connection with the results of skilled observations often leads to conclusions which are manifestly wrong and even absurd. The values found by this formula are expressions of *possibilities* (and sometimes of impossibilities), while those found by observation, even when very small numbers are used, are expressions of *probabilities.* Mathematical arguments are of little or no value in comparison with the actual results of observation and experiment, and there is no more justification for applying them in connection with the results of blood examinations than there is for applying them to such problems as the flight of mosquitoes. In regard to these insects actual observations prove that the whole justification for a mathematical argument

* This is the figure given in the printed paper. In the table exhibited at the meeting a smaller admittance was given shewing not an increase of 4 % but a diminution of 1 %.

is annulled by the fact that their flight is not "random" but "purposeful." Major James thought that the gloomy future for anti-malarial measures predicted by Major Ross was not justifiable, because it was evident from the papers of Captain Christophers and Dr. Bentley, as well perhaps as from his own paper, that we are entering upon an era of greater knowledge as regards the true factors governing the epidemiology of malaria, and with greater knowledge must come greater power and more precise measures. Continuing, he referred to Major Ross's statement that he had always recommended quinine prophylaxis in preference to drainage operations for rural areas, and said that this recommendation implied that quinine prophylaxis is the correct method for 90 per cent. of the inhabitants of India, because more than 262 million out of the 294 million inhabitants of India live in rural villages. Thus any system of prevention which omits to recognise that the problem of the mitigation of malaria in India is the problem of its mitigation in small villages must be futile, and the constant recommendation of drainage operations as the only right plan of reducing malaria gives this method a special prominence which tends to prevent the urgent necessity of establishing a thoroughly adequate organisation for quinine prophylaxis on a national scale. It was but most inadequately applied at present, as the number of pice packets of quinine sold annually was less than the number of vaccinations performed during the year. Even at Mian Mir quinine was ordered to be issued regularly, but he could not say whether it was taken.

[*Copy of letter sent by Major Hooton, I. M. S., to the Indian Medical Gazette.*]

RAJKOT, KATHIAWAR,
24th April 1909.

To
THE EDITOR,
Indian Medical Gazette.

SIR,—I shall be obliged if you will allow me space for a few remarks with reference to the interesting discussion on malarial prevention which took place at the recent Bombay Medical Congress. It is probable that others who were present on that occasion may have been taken somewhat by surprise, as I must admit was my own case, and I fancy also that there must have been a considerable number whose experience would have agreed with mine in supporting Professor Ross' views, broadly speaking, as contrasted with those of the quinine school. But it is not easy to marshal one's arguments to meet an unexpected line of attack, and the discussion had in this instance, it seemed to me, got into a *cul de sac* from which it would have been difficult to recall it. Professor Ross had, indeed, admitted that all available means of prevention should be made use of though at the same time laying very great stress on mosquito destruction, but his opponents, so far as I could gather, had little or nothing to say in favour of this measure, and pinned their faith almost entirely on quinine. Now this, I would urge, is not the right way to approach the subject. A very distinct dividing line may be drawn between irrigated tracts and large areas of marshland such as I understand are to be found in the Reman Campagna, on the one hand, and the average Indian station or native town, such as I have seen it in the Deccan and Gujarat, on the other. It may or may not be practicable, with the means at present at our disposal, to deal effectively with the former conditions on Ross' lines—probably not as most of the speakers seemed to agree—but, so far as my experience goes, it emphatically is possible to effect a very great change for the better by mosquito destruction in localities of the second class. Working on a small scale I have personally achieved the best results in two district prisons, and in other localities not so easily controlled, the effect being demonstrable, not only in the almost complete disappearance of mosquitoes, which were previously present in swarms and caused great annoyance, but also of the disease to which they gave rise ; and in addition to these instances, it is easy to call to mind places where one could point with certainty to some dominant factor in the situation, to deal with which would obviously solve the whole question for that particular area, and would ensure the absence of any natural breeding water in it. For instance, I know one very malarious town of some 5,000 inhabitants, which is traversed by a nalah containing for the greater part of the year almost stagnant water, and surrounded by a dry expanse in which, except for a few mud-holes, mosquitoes can find no breeding water. Can anyone doubt that under conditions such as these anti-mosquito operations would be of the greatest use ? This is a state of things which is very common in India—perhaps the most common of all ; and yet the advocates of quinine prophylaxis appeared to leave it out of consideration.

It is a curious reflection that a casual visitor, perhaps even our distinguished guests from the Phillipines and elsewhere, must have left the malaria section of the Congress under the impression that the Ross school was without honour in this country, and it is partly for this reason, and partly also because of the very unfortunate effect which the trend of the discussion may have on local authorities and the Government to which we have to appeal for funds to undertake anti-mosquito measures, that I should like to place my own views on record. Professor Ross himself seems to partake of this impression, and to believe that little or nothing is being done in India on the lines recommended by him, but in this I am convinced he is entirely wrong. Is there a Civil Surgeon in the country who does not —if only in his own compound—undertake anti-mosquito operations : if so he is either a very fortunate or else (in my view) a very misguided man. On the contrary, I imagine that by this time such methods are regarded as so much a matter of course, and their utility, under ordinary conditions in the average station, is so well recognised, that nobody troubles to write about them. And the credit for this lies with Professor Ross, who had at the beginning to fight a very up-hill fight to get a hearing at all, and is still, it would appear, liable to be called out for service in the same cause.

I am, Sir, Yours faithfully,
A. HOOTON, MAJOR, I.M.S.,
Agency Surgeon, Kathiawar.

RAT-FLEAS WITH THEIR SPECIAL REFERENCE TO THE TRANSMISSION OF PLAGUE IN JAPAN.

BY PROF. S. KITASATO, M.D., F.R.S., HON. F.R.S.M. AND C., &C., &C.

Read by Professor Shiga.

Since the discovery of the plague bacillus, suggestions have been made to the effect that certain insects specially fleas may serve as the transmitters of the germ and evidence has been accumulated from epidemiological observation as well as from experimental investigation. The final demonstration that the rat-flea played a most important part in the epidemiology of plague has been shown by the systematic investigation of the Plague Research Commission, while Liston has proved conclusively that the common Indian rat-flea, Pulex cheopis, is the essential agent in the transmission of plague. It must be owned, however, that as different species of fleas thrive on rats in different parts of the world, it cannot be easily assumed that Pulex cheopis

should be everywhere the transmitter of plague. The Commissioners and Dr. Verjbitski have independently demonstrated by experiment that fleas other than the common Indian rat-flea,—namely, Ct. musculi, Cer. fasciatus, Pulex irritans, etc.,—may spread plague among the rat family. But these species have not yet been proved to be the real transmitters of plague under normal conditions.

In Japan, it has been found that the fleas commonly infesting rats do not belong to Pulex cheopis, but Ct. musculi and Cer. anisus. Further, the fleas are most prevalent in the hot summer, while plague epidemics take place usually in the cooler season. Thus the non-coincidence of the season of prevalence in plague and fleas does not favour the flea-theory. My present work was planned with the view of determining the still uncertain fauna of rat fleas in Japan, and at the same time to see how far they may play their part as the propagators of plague. The observations were made conjointly with my assistants Prof. Miyajima, Dr. Koizumi, and Mr. Takano at Yura, where a plague epidemic broke out in 1908.

I.—Observations on the Plague Epidemic at Yura.

Yura is a fishermen's town situated on the southern sea-shore of *Awaji* Island, which lies at the east entrance of the inland sea. It contains 1,708 households with a population of 7,168. It occupies a strip of land stretching from north to south. Poor small houses stand crowded along the narrow streets so that the rat can easily migrate from house to house. The chief products of the place, fish, etc., are daily carried to *Osaka* and *Kobe* by boats where the supply of the necessaries of life is re-embarked. Thus a constant and bustling communication by boats gives an easy access to the transmigration of rodents.

Since 1906, when a number of cases of plague occurred at *Sumoto* village, four miles away from *Yura*, sanitary measures to eliminate rats from the latter also have been adopted. A plague-rat was detected in December 1907. Since then a few infected rats were found monthly, which indicated the unmistakable evidence of the spread of an epizootic, and in August 1908, a human case occurred. From the fact that the locality of the first occurrence both in man and rat was near the piers and that plague was prevalent (though in a mild form) both at *Osaka* and *Kobe*, we may infer that the germ was introduced from these two cities.

The epidemic broke out in August 1908, when a rat plague as well as human cases occurred, which developed rapidly in September and October, attacking the town from the North end to the South. It ceased in November, with the total of human cases of 109, the ratio of attacks being 1·2 per cent. Such an epidemic with so many cases in so short a time, is rarely met with in Japan.

The 109 cases can be divided into the following classes according to their types of infection :—

Bubonic plague	82
Septicæmic	22
Skin plague	1

The fact that there were so many cases of septicæmia which developed no bubo is to be noted. Again the 82 bubonic cases can be still further sub-divided as follows according to the situation of buboes :—

Femoral and inguinal	45
Axillary	22
Cervical	15

Of the 15 cervical cases, except 2, all were under 12 years of age. Such is often the case in other epidemics. It would seem that they contracted the disease not by the bite of the flea but by nibbling some contaminated food or other.

Of the total 109 cases, 43 were diagnosed to be plague by the examination of the dead, while 66 were received into the isolation hospital, where they received serum treatment together with extirpation of buboes. The result was that 35 recovered and 31 died, the mortality rate being 46·9 per cent. If the non-treated cases were to be added, the rate would increase to 67·8 per cent.

II.—Observations on Rat-fleas with Special Reference to Plague.

As the first step in the investigation concerning the part played by fleas in the epidemiology of plague, they were collected at Tokyo and its vicinity until the month of September 1908, that is just before the work was carried out in *Yura*. 711 fleas were examined in all.

They were identified to be as follows :—

1. Pulex irritants, Linn.
2. Ctenocephalus felis, Bouche.
3. Ctenocephalus canis, Curtis.
4. Ctenopsylla musculi, Dug.
5. Ceratophyllus anisus, Rothschild.
6. Ceratophyllus sp.
7. Ceratophyllus n. sp.?

Pulex irritans was found on man, Ctenocephalus felis on cats, Ctenocephalus canis on dogs. They might be safely excluded from our consideration, as they have no connection with rats, while Ct. musculi, Cer. anisus and the last two Ceratophyllus species are found on rats and mice. Of these species of rat-fleas, Ct. musculi is a well known cosmopolitan species and the remaining three resemble Cer. fasciatus, being provided with ctenidium on the thorax only. Cer. anisus was first described by Rothschild and constitutes one of the commonest species of the rat-fleas in Japan. The two last mentioned are rare species and not yet identified with any hitherto described. Amongst those that are provided with thoracic ctenidium only, Cer. anisus is the most numerous and therefore for the sake of convenience, I will bring these three under one group of Ceratophyllus. Pulex cheopis, which is so prevalent in India, had been never found in Japan, until it was found in *Yura* and subsequently in various other places, though small in number. By these facts, it would seem that the flea fauna of Japan is different from that of Europe, India, America, Australia and the Phillipines. The Formosan fauna, however, agrees with that of the Phillipines.

During the month of October, when plague thickly infested the town, 2,130 fleas were collected from several sources in *Yura*, and the result of the examination showed that Pulex irritans was found on man, Ct. felis on cats

and Ct. canis on dogs exclusively. 551 were collected from house-rats, which consisted mostly of the common Indian rat-fleas, Pulex cheopis, *i.e.*, 255 or 46 per cent. Again of the 265 fleas collected from the houses by letting guinea-pigs run free, 239 or 90 per cent. were found to be the common Indian rat-fleas. Thus the fauna of the fleas in *Yura* was proved to be different from that of any other place in Japan. Further observation in *Yura* during the period from October to December showed that out of the total number of 835 collected during the season, 8 were of Ct. felis, 213 of Ct. musculi, 235 of Ceratophyllus species and 380 of Pulex cheopis. The last one showed as high a ratio as 45·4 per cent.

As many rats as could be obtained were examined in order to determine the number of fleas a rat may harbour, and it was found that a healthy rat carried 2·2 fleas, on an average, while a plague-rat carried 11·3. This wide difference between their numbers agrees with the reports from India and Sydney. Then again the best part of the fleas, *i.e.*, 1·1 in the healthy rat and 5·3 in an infected one, consisted of Pulex cheopis.

In order to determine the ratio of the number of fleas in plague-infected and non-infected houses, guinea pigs were let loose in several houses and the fleas on them were collected. 33 guinea-pigs that were let free in 12 of the houses gave only 16 fleas, whereas from 56 guinea-pigs from the same number of plague-infected houses, 249 fleas were collected. The average number of fleas was found to be 20·7 from plague-infected houses, as compared with 1·3 in the non-infected. Again, if we apportion the number to one guinea-pig in each case, the ratio in the former comes to 9·6, and in the latter, 0·4. Of the total of 249 fleas from the plague-infected houses, 227 or 90·1 per cent. were identified to be the common Indian rat-flea. The intimate relation existing between the prevalence of plague and this species of fleas becomes thus manifest.

The above facts led me to presume that as the number of fleas increased, the percentage of the bacteria carriers would also correspondingly increase; such proved to be the real state of affairs, as at *Yura* the proportion was 17·7 per cent. out of the 1,093 collected during October, and 7·3 per cent. out of the 791 during November. The percentage of the bacteria carriers alone was 22·5 per cent. in October and 10·2 per cent. in November. This sudden fall of percentage indicates the actual decline of the epidemic.

The percentage of bacteria carriers was calculated from the 1,691 fleas collected from rats exclusively, and the following result was obtained.—

Collectively...	... 23·2	per cent.
Ct. musculi ...	... 34·0	„
Ceratophyllus species.	22·1	„
Pulex cheopis	... 17·0	„

Again, out of the 207 collected from the plague-infected houses, 49 were proved to carry bacteria, making the percentage of 23·6, that of the common Indian rat-fleas alone being 22·3. This disproportion between the percentage in the Indian rat-fleas in both cases, may be explained on the ground that the infected houses are thickly infested with the germ.

The above observation was made only with the aid of the microscope, which is but an imperfect help in this regard. Cultural and animal tests were therefore made with the 43 rat fleas collected from the infected houses and 15 human fleas collected from the beds of patients. These proved most conclusively the presence of virulent pest bacilli in every species of fleas.

Numerous observations have shown that the percentage of bacteria carriers varies according to the change of environment, and, therefore, no distinct variation between each separate species can be established. This fact may be still further demonstrated if a number of fleas of various species is allowed to bite an infected rat, they will present no distinct difference so far as their percentage of the bacteria carriers is concerned.

The variation of the number and species of fleas, which occur between the sources of collection, whether it be the infected or the neighbouring houses or the non-infected houses, as well as the infection in guinea-pigs when they are employed, are to be still further explained. 56 guinea-pigs were let loose into 12 plague houses. In 8 houses, 15 animals contracted the disease and died. Out of the 249 fleas collected in the experiment, 227 were identified to be Pulex cheopis, of which number 22 per cent. carried pest bacilli. 33 guinea-pigs were let loose into 12 non-infected houses. None of them contracted disease. The total number of fleas collected in them was only 16, which were all proved to be free from the germ. Then again, the collection of fleas out of the 17 infected and their neighbouring 7 houses, which were standing in a like condition was made. The percentage of bacteria carriers in fleas and the occurrence of infection in guinea-pigs were found to present no difference. It was noticed that the common Indian rat-fleas were found abundantly. For instance;—in a house neighbouring an infected one 2 guinea-pigs were run free and 4 of Ceratophyllus and 48 of Pulex cheopis were collected, 6 of the latter being bacteria carriers, while both experimental animals died of contamination. There is scarcely any doubt as to the possibility of transmission effected by rat-fleas, and it is a noteworthy fact that in Japan as well as in India Pulex cheopis plays an important role in the plague epidemic.

III.—Observations on the Distribution of Rat-fleas.

Is Pulex cheopis, which has been found to be the chief transmitter of plague at *Yura*, a native to Japan? That is a question yet to be proved, for the flea-fauna of Japan has not yet been explored by any entomologist.

Since October 1908, I have collected 4,617 fleas from rats in 8 places in *Awaji* Island in order to determine what kind of fleas thrive in the vicinity of *Yura*. I found 5 of them to be human fleas, 18 cat's and all the rest those of the rat. Of the latter, 2,706 were identified to belong to the Ceratophyllus species, and 955 Ct. musculi, while 933 were the common Indian rat-flea. The Indian rat-fleas, therefore, formed 20·2 per cent. of the whole number. They were practically absent in one

of the 8 places, *i.e*, in *Shizuki*. In *Iwaya* they averaged 42·2 per cent., in *Ushiwo* 24 per cent. and in the remaining 5 places they amounted to less than 20 per cent. In *Yura* they averaged 45·4 per cent.

In proportion of their number, Ct. musculi prevails in *Nushima* and *Ichimura*, and Ceratophyllus species in *Shizuki*, *Sumoto*, *Monobe*, *Ushiwo* and *Fukura*, and therefore, it will be clear that Pulex cheopis is in no wise the most prevalent species in *Awaji* Island. Besides *Awaji* Island, my investigation has been restricted to *Tokyo*, *Yokohama*, *Nagoya*, *Kyoto*, *Osaka*, *Kobe*, *Nara*, *Wakayama*, *Yuasa*, *Takamatsu* and the total number of rat-fleas obtained amounts to 2,713 outside of *Awaji*, up to the present time. Only one of this number was a cat-flea, the rest being rat-fleas, of which 1,804 were Ceratophyllus species, 743 Ct. musculi, while 165 only were Pulex cheopis. The percentage of the latter is 6 per cent., which fact alone explains that it is not the predominating species in Japan.

The following table shows this in detail ,—

Name of the source.	Per cent. of Pulex cheopis.
Tokyo	2·7
Yokohama	2·6
Kyoto	1·8
Osaka	12·2
Kobe	28·7
Yuasa	19·0
Takamatsu	1·7

Thus we find that in all the places except *Yuasa Kobe* and *Osaka*, where either human or rat plague occurred or is still present, the percentage of Pulex cheopis is very low and it is by far the lowest or nil as in *Wakayama*, *Nara* and *Nagoya*.

Then again, in *Tokyo* and *Yokohama*, I could demonstrate the presence of Pulex cheopis mainly on rats captured near the ports. And in other places, where less communication is available no Pulex cheopis was found. In *Yokohama* on the living rats (Mus rattus and Mus Alexandrinus) collected in the ships arrived *via* various ports in India and southern China, I could find only Pulex cheopis. In literature, we find that Tiraboschi observed in Genoa that 40 per cent. of the rat-fleas in ships were of Pulex cheopis and Gauthier and Raybaud report that in Marseilles 25 per cent. of rat-fleas in ships were Pulex cheopis, which decreased in proportion as the distance from the shore was reached. From these facts we may infer that Pulex cheopis can be distributed even to a far distance by ships.

The geographical and quantitative distribution of rat-fleas in Japan, so far as it has been hitherto investigated, appears to consist of the uniform predominance of Ct. musculi and the Ceratophyllus species, while Pulex cheopis disappears as the distance from the sea-shore increases. From the fact that Pulex cheopis can only be found in the open ports and abundantly in a place where plague epidemic is raging or has raged, we may say that it is not a native rat-flea but one that has been introduced from abroad.

Conclusion.

My observations in Japan reach no further but lend support to the infallibility of the results of the elaborate investigations made by the Indian Plague Commission. Though small in number, the presence of Pulex cheopis provides with all the necessary conditions for the spread of plague, and when the germ is introduced into such a place, it will produce an epizootic among the rat-family which will find no difficulty in finding human victims in its turn. I have been entertaining the view that in Japan plague has been introduced from abroad. It is still further confirmed by the present investigation, which showed that the unwelcome guest, Pulex cheopis, is continually flowing in at our sea-ports. As has been suggested by me, the only means with which we may save mankind from this dread of plague would seem to consist in annihilating the evil at the very source of the pestilence. An International Conference on Plague will be chiefly instrumental in affording us all possible facilities in solving the plague problem at large. The Bombay Medical Congress bears this international character, for it has been planned on a large scale, covering nearly all the leading countries in the Far East, and it is my sincere wish to encourage the holding of this kind of Congress more frequently.

On Professor Shiga concluding the reading of Professor Kitasato's paper, Surgeon General Hamilton, proposed that the best thanks of the Congress are due to Professor Shiga for reading the paper, and undertaking a long journey for the same. The vote was carried with acclammation.

DISCUSSION.

Major G. Lamb said that he and his co-workers had ample reason to congratulate themselves that their observations on the etiology of plague had been confirmed by no less an authority than Professor Kitasato.

THE ETIOLOGY AND EPIDEMIOLOGY OF PLAGUE.

By Major GEORGE LAMB, M.D., I.M.S.,

Member of the Advisory Committee for Plague Investigations in India.

I.—*Introduction.*

I propose in the present communication to confine myself strictly to one aspect of the plague problem, namely, the etiology and epidemiology of the disease, leaving out the important questions of prophylaxis, seasonal prevalence and recrudescence, which will, I understand, be dealt with by other members of the Congress. I propose to divide my subject into various headings and in as brief a manner as possible to state under each heading the facts which have now been

definitely proved and which may be said to be outside the range of controversy. By doing so I hope to be able to place before you the true position of the plague problem as it now stands.

II.—*Bacteriology and Pathology.*

A few words are necessary on the bacteriology and pathology of the disease, but only to those points shall I refer which have a very direct bearing on the question before us. Plague is an acute specific disease, due to a bacillus which was isolated by Yersin and Kitasato in 1894. The bacillus pestis is easy of cultivation, is non-sporing and very soon loses its vitality on exposure to sunlight, drying and other external agencies. It is, in short, a delicate organism, which can have no existence in nature outside an animal body.

With the exception of a few primary pneumonic cases (about 3 per cent. of the total) the plague bacillus gains entrance to the body through the skin. Practically all observers are agreed on this point, there being no evidence worthy of the name in favour of infection of man by the alimentary canal or by any other channel. Gaining entrance through the skin it passes up the lymphatics and, filtered out by the glands, gives rise to swellings of these glands, clinically known as the 'bubo.' The blood may become infected later on, or even sometimes, but rarely, early in the disease. The bacilli in man are found in greatest number in the bubo; in the blood, if present at all, they are as a rule few in number and in greatest number just before death. They are present in the urine only in some cases and then as a rule few in number. It is in this, connection to be noted that the urine of plague cases is not infective to animals when rubbed into abrasions of the skin. The fæces are not infective or only very rarely so. Therefore, from a bacteriological point of view, it is difficult to see how an ordinary bubonic plague case is dangerous, and this conclusion is, as we shall see, in harmony with the epidemiological evidence which goes to show that a case of bubonic plague in man is not in itself infectious and plays no part in the spread of the epidemic.

III.—*Relation of Rat Plague to Human Plague.*

It is a very old observation that accompanying a plague epidemic there is a serious mortality amongst the rats, which epizootic has been noted to precede the epidemic. After the discovery of the plague bacillus the rat disease was soon shown to be true plague. The relationship between the rat epizootic and the epidemic has in recent years been studied in various parts of the world, especially by the present Plague Commission in Bombay and in two villages in the Punjab. What have been the results of this study? A few words first about the rats. In Bombay City there are two species of rat of which account may be taken, namely, Mus decumanus and M. rattus. The former inhabits stables, outhouses and sewers, while M. rattus is a house rat, a true companion of man. In the mofussil villages of India only one of these species, namely, M. rattus, is found. It has in the villages the same habits as in Bombay. In Bombay City it was found that the decumanus epizootic preceded that amongst M. rattus by an average interval of 10 days and on the total evidence it was concluded that the rattus epizootic was dependent on the decumanus epizootic. Further, the relationship between the rattus epizootic and the epidemic both in Bombay and in the up-country villages, in time, in place and in quantity, was so conclusively demonstrated as to leave not the slightest doubt that the latter is directly attributable to the former. This conclusion will no doubt be found to hold good for the whole of India and probably for the great majority of the plague epidemics in other parts of the world.

4.—*Method of Transmission of the Infection from Rat to Rat and from Rat to Man.*

Having arrived at the important conclusion that plague in the rat is wholly responsible for the human disease, we have next to ask ourselves the question how the bacilli are conveyed in nature from rat to rat and from rat to man. A little consideration will show that there are several possibilities. The evidence for and against each of these possibilities I propose now to state briefly.

(*a*)—*Direct Contact.*

Let us first deal with infection by direct contact. The evidence against this means of infection playing any part in the spread of plague is overwhelming. Thus hundreds of experiments were carried out by the Commission, in which it was shown that healthy animals could live in contact with plague animals under all sorts of conditions and, if fleas were rigorously excluded, did not contract the disease. It was also shown that the young could be suckled by plague-stricken mothers and not become infected. Further it was found that in badly infected houses animals which were protected from direct contact with others which might be infected still in many instances contracted the disease.

(*b*)—*Aerial Infection.*

Aerial infection can be as easily excluded as contact infection. While the same experiments which negative the latter supposition can be used to show that aerial infection does not take place, experiments by suspending animals in infected godowns and observations in plague infected houses all definitely prove that aerial infection, as far as the bubonic variety of the disease is concerned, does not exist.

(*c*)—*Soil Infection.*

It has often been put forward that the plague bacillus gains an entrance to the animal body, especially in the case of man, by means of contaminated soil being rubbed into abrasions or cuts, the soil having been contaminated with the excreta of rats or human beings. This theory, however, receives no support from recent work. I have already said that the plague bacillus is a delicate organism and all experiments go to show that contaminated soil or floors, even if grossly contaminated, very soon loose their infectivity, so soon as to render them harmless after a few hours. We have also seen that neither the fæces nor the urine of rats or man are highly infective

agents, when the test of infectivity is one which would be at all likely to occur in nature. This is in harmony with the observations, in which animals lived in godowns in intimate contact with plague animals and did not contract the disease. In these experiments the floors were never cleared and soon became badly soiled with the fæces and urine of the plague animals.

Further, in plague infected houses no competent observer has ever isolated the bacillus from the floors or walls. Finally, many experiments have been made in plague houses all of which go to show that the infection does not reside in the soil. Animals placed in these houses but carefully protected from soil infection often contract the disease. And most important, houses which have been carefully and thoroughly disinfected with a strong acid solution of perchloride of mercury are just as infective to guinea-pigs as houses which have not been treated by any disinfectant.

(*d*)—*Transmission of Infection by means of Food.*

It has been contended by a school of pathologists, which had its head-quarters at Hong Kong, that infection through the alimentary canal by means of contaminated food was the commonest, if not the only, method of infection. This theory must now, however, be dismissed. We have seen that as far as man is concerned all competent observers are agreed that the *post mortem* findings leave no doubt that alimentary infection does not take place and that the infection is in the great majority of cases by way of the cutaneous surface.

In the case of rat-to-rat transmission a certain amount of support can be obtained in favour of alimentary infection from the fact that in the laboratory it is possible to infect those rodents by feeding them on grossly contaminated material. It is argued therefrom that in nature rats become infected through eating the carcasses of their comrades dead of plague. But it has been possible completely to upset this argument by means of the following observation. In rats infected in the laboratory by feeding, the mesenteric glands are the site of the primary bubo in 72 per cent. of the cases, while although 6,000 rats dead of plague in nature have been carefully examined not a single mesenteric bubo was found. Other experimental data can also be brought forward against food infection. It has never been possible to infect animals by feeding them on the excreta of plague cases or, as happened in the godown experiments, on food grossly contaminated with the urine and fæces of their plague-stricken comrades. Further, young guinea-pigs do not contract the disease when suckled by mothers suffering from the disease.

With all this evidence in front of us we are bound to conclude that the transmission of infection by food plays no part in the spread of plague in nature either from rat to rat or from rat to man.

(*e*)—*Transmission of Infection by Means of the Rat Flea.*

We have now to consider the last possible method of transmission of infection, namely, that by some suctorial insect.

It was soon apparent to the Plague Commission, that if any biting insect was the agent of transmission of the bacillus from rat to rat and from rat to man, fleas and those species of fleas which infesting the rat would also bite man were practically the only insects which need be considered. In Bombay only one species, namely, Pulex cheopis, fulfilled these conditions. In the Punjab villages another species, Ceratophyllus fasciatus was also found on rats but only in the proportion of 2 per cent. to 98 per cent. of P. cheopis. The following remarks, therefore, refer to P. cheopis.

What evidence is there that the rat flea is the transmitting agent from rat to rat and from rat to man?

1.—*Experiments in the Laboratory.*

An enormous number of successful transmission experiments have been carried out with rat fleas, all other possible means of infection being rigorously excluded. Rats, guinea-pigs and monkeys have all been successfully infected in this way. The possibility of flea transmission has therefore been proved beyond a doubt. It has also been shown, that, if the proper conditions are observed and a susceptible animal like the guinea-pig used, nearly 100 per cent. of successes will be obtained.

2.—*Experiments in Godowns.*

These observations were made in specially constructed cabins or godowns, in the compound of the Parel Laboratory and which we shall be pleased to show to any of you who are interested. A very great number of experiments with guinea-pigs especially, but also with rats and monkeys, under various conditions and at all seasons of the year, have been made in these godowns. The details of these experiments have been fully published elsewhere, so that for our present purpose I need only cite the conclusions which can be drawn from them, and the importance of which cannot be overrated :—

(*a*) Close and continuous contact of plague-infected animals with healthy animals, if fleas are excluded, does not give rise to an epizootic among the healthy animals. As the godowns were never cleaned out, close contact includes contact with fæces and urine and eating of food contaminated with fæces and urine of infected animals. Close contact, even the sucklings of young by plague-stricken mothers, does not give rise to the disease.

(*b*) When fleas are present, the epizootic, if it does start, varies in severity and rate of progress according to the season of the year and the number of fleas present. The season in which epizootics are readily produced experimentally and spread rapidly corresponds with that of the plague epidemic.

(*c*) An epizootic of plague can occur in a godown containing infected fleas without direct contact of healthy animals and infected animals.

(*d*) In an infected godown the infection is effective in proportion as the test animals are accessible to fleas.

(*e*) Infection can take place without any contact with contaminated soil.

(*f*) Aerial infection is excluded.

(*g*) The experiments lead to the conclusion that fleas and fleas alone were the transmitting agents of infection.

3.—*The Rat Flea the Agent of Transmission of Infection from Rat to Rat in Nature.*

As we have already excluded all other possible means of infection in nature but the rat flea, it seems almost superfluous to bring forward a piece of direct evidence on this point. This evidence is obtained from a comparison of the site of the primary bubo in animals, both rats and guinea-pigs, infected in nature and in animals infected in the Laboratory by means of fleas. Without giving the actual figures in this place, I may say that the close correspondence between the distribution of buboes in these two groups of animals points to the conclusion that the mode of infection is the same in both cases, namely, the rat flea.

4.—*Infection in Plague Houses due to Infected Rat Fleas.*

We have now to consider for a moment the direct evidence which points to the infection in plague houses being due to infected rat fleas and to nothing else. This evidence is summarised as follows:—

(*a*) Guinea-pigs allowed to run about in plague houses may take plague; 21 per cent. of plague houses are found to infect guinea-pigs. The same results are obtained if the houses have been previously disinfected with a strong solution of acid perchloride of mercury. Now, we know that this solution readily kills the plague bacillus in the soil, &c., but has no effect on fleas, which can be captured in as large numbers before as after disinfection.

(*b*) Fleas derived from dead plague-infected rats found in houses or from healthy animals placed in plague houses give plague to fresh animals in the Laboratory.

(*c*) Animals placed in plague houses and protected from fleas never take plague. Other animals placed in similar cages but to which fleas have access often develop the disease.

(*d*) More than 30 per cent. of the fleas trapped in plague houses on animals or otherwise contain abundant living and virulent plague bacilli in their stomachs.

(*e*) Houses which are definitely proved to be plague-infected contain on an average nearly 3 times the number of rat fleas contained in houses which are only presumably plague-infected, and 12 times the number contained in houses which are free from suspicion.

From all these facts the only conclusion which can be come to is that in a plague-infected house the infection is due to infected rat fleas and to infected rat fleas alone.

5.—*The Rat Flea the Agent of Transmission of Infection from Rat to Man.*

The direct evidence which is available to prove that the infection from rat to man is by means of the flea, is stated as follows:—

(*a*) We have seen that almost all observers are agreed that in nature the bacilli gain entrance to the body of man through the skin.

(*b*) An epidemiological piece of evidence is of the greatest interest and importance. It is as follows:—

There is, as we have seen, a definite time relationship between the rattus epizootic and the epidemic. The interval between these two phenomena is on an average 10—14 days and is best explained on the supposition that there is an intermediate agent between the rat and man. On this supposition the interval is divisible into the following periods:—

(1) *Period* elapsing before the rat flea, coming from the dead rat, bites man, namely, 3 days. This is arrived at by a large series of observations made in the laboratory.

(2) *Incubation period* of human plague, average of 3 days.

(3) *Duration of illness* of fatal human plague cases, namely, average of $5\frac{1}{2}$ days.

(*c*) Another piece of evidence of the greatest importance is, the rat fleas when hungry readily bite man. This has been demonstrated by experiments in the laboratory and by observations in the godowns and in plague-infected houses.

Taking all these facts in conjunction with all the experimental and other evidence which goes to show that the rat flea and the rat flea alone is the agent by means of which rats become infected, and that the infection in plague houses is solely due to the presence therein of infected rat fleas, we can, with the greatest confidence, conclude that that the agent of transmission between the plague rat and man is the rat flea and the rat flea alone.

Before concluding, I would say a few words on three important questions which might now well be asked. By obtaining answers to these questions we shall clear the way for those who come after me and who have to speak on prophylaxis.

6.—*The Relation of the Human Plague Case to the Spread of the Epidemic.*

First, we may well ask what is the relation of the human plague case to the spread of the epidemic. If the epidemic is solely attributable to the rat epizootic, it almost follows that the human plague case can play no part in the spread of the epidemic, and all evidence is in favour of this most important deduction. The experience in plague hospitals; the observations made by the Plague Commission which show that imported plague cases *per se* have no influence on the spread of the epidemic; the fact that in the great majority of cases no history of contact with other plague cases can be obtained; and the comparative rarity of multiple cases in a house, all support the conclusion that the human plague case plays no part in the spread of an epidemic.

7.—*Relations of Insanitary Conditions to the Spread of Plague.*

Secondly, it has been often put forward that insanitary conditions influence the spread of plague. With the object of enquiring into this relationship a large mass of data was collected and sifted by the

Plague Commission. They came to the conclusion that, while insanitary conditions have no influence directly on the spread of the epidemic they have a very great indirect influence, in so far as they favour the infestation of rats and the living together of rats and man. The conditions which tend towards these ends are briefly stated as follows:—The structure of buildings which renders them easily permeable to rats and which affords shelter in the walls, roofs, &c., to these rodents; any system of sewers and drains which communicating openly with the houses shelters rats and gives means of access and exit; the building of dwelling houses in the same tenements as or in close proximity to stables, godowns, shops, &c.; the abundant food-supply, both outside and inside houses, left freely accessible to rats; and lastly, the habits of the Indian people which do much to foster rats. They are more or less indifferent to their presence in the house; they fill the house with all sorts of rubbish and useless articles which afford excellent shelter and breeding places for the house rat: they store supplies of raw material, gram, ghee, &c., in chests and pots which are easily accessible to rodents. All these conditions, call them insanitary if you like, favour rat infestation and are thus indirect causes of the spread of plague.

8.—*The Importation of Infection from an Infected to an Uninfected Locality.*

Thirdly, how is plague imported from an infected to an uninfected locality? A moment's consideration will show that importation must be either by means of infected rats or by means of infected fleas. There is no evidence that migration of rats takes place, but it is true that infected rats might be carried from place to place in merchandise, *e.g.*, hay, cotton, furniture, &c., on the other hand there is much evidence to show that infected rat fleas can easily be carried from a plague house to an uninfected locality. They are almost always conveyed by human agency, namely, by healthy men or by plague cases or in their belongings, so that we may conclude that plague spreads from place to place by human agency.

9.—*General Conclusions.*

Finally, I beg to put forward the following general conclusions which, as regards the question of prophylaxis, are of the greatest importance:—

1. Bubonic plague in man is entirely dependent on the disease in the rat.
2. The infection is conveyed from rat to rat and from rat to man solely by means of the rat flea.
3. A case of bubonic plague in man is not in itself infectious.
4. Insanitary conditions have no relation to the occurrence of plague, except in so far as they favour infestation by rats.
5. Plague is usually conveyed from place to place by imported rat fleas, which are carried by people on their persons or in their baggage. The human agent not frequently himself escapes infection.

DISCUSSION.

Dr. Sukhia in the course of his remarks referred to the work of Ichigama, a Japanese Physician who did not quite agree with the views formulated by Major Lamb, and held that the abdominal and intestinal form of plague lent support to the theory that food infection played by no means an unimportant role in the spread of plague. Whilst Dr. Sukhia was discussing his theory, the President informed him that Ichigama no longer held those opinions, and had latterly changed his views Dr. Sukhia said that under these circumstances, he would close his remarks as nothing more was to be said, and commended Ichigama for his moral courage in admitting his errors.

Dr. Choksy said that from his clinical experience now extending over 13 epidemics he was able to confirm Major Lamb's conclusions. Ever since the early days of plague, he had held that the infection in plague took place through the skin, and although our knowledge then was not so accurate or extensive as now, the study of the primary cutaneous manifestations of the disease, their bacteriological examination, as also his description of the mode of development and progress of the cellulo-cutaneous type of plague in 1897, further confirmed the views then propounded. The Plague Research Commission has now set the seal of its approval upon the cutaneous entrance of the virus, by tracing the connection between rat and human plague through the rat-flea. In all his experience, he had not come across a single case of primary abdominal or intestinal infection, and numerous autopsies had failed to show evidences of any such as all the changes observed had been found to be secondary to infection in other parts of the body. No primary mesaline bubo has been observed in man. That food cannot convey the infection has been demonstrated by some instances within his knowledge where plague-infected rats had fallen into food ready cooked and prepared for consumption, that had been consumed with out any ill effects. That plague does not spread by direct contact between the sick and the healthy has been repeatedly shown by numerous instances wherein the same bed was shared throughout the whole period of illness without any harm. Aerial infection can similarly be excluded, as no instances have been recorded although a number of thickly populated buildings have existed to windward of the Arthur Road Hospital for some years. Soil infection is also negatived by actual demonstration, as during the early epidemics the foors at the Arthur Road Hospital, consisted of earth, easily permeable, in which the excretions of the patients could readily soak. Numbers of patient's relatives and friends used to squat by the bed-side at day, and sleep at night, and in no single instance infection from the soil could be traced.

The above data from clinical sources, therefore, fully bear out the observations of the Commission.

ON THE CLINICAL SIGNIFICANCE OF SEPTICÆMIA IN HUMAN PLAGUE.

By Khan Bahadur N. H. CHOKSY, M.D., (Hon: Causâ) Freiburg,

Special Assistant Health Officer, Bombay Municipality, in charge of Arthur Road Infectious Diseases and Maratha Plague Hospitals, Bombay.

I.—BACTERIOLOGY OF SEPTICÆMIA.

The importance of the study of septicæmia in human plague becomes sufficiently manifest when it is realised that the ultimate fate of the patient is practically determined by the presence or absence of the bacillus pestis in his blood. The earlier investigations into the subject by the Austrian Plague Commission, Calvert, Berestneff Mayr, the present writer, and Greig have been summarised by the Plague Research Commission* and they show that septicæmia was present in 40 to 60 per cent. of the cases examined at the Arthur Road and Maratha Hospitals. The Commission undertook a fresh line of inquiry into the subject directed towards the quantitative estimation of the degree of septicæmia at various stages of the disease, as also into the infectivity of the excreta of plague patients, especially of the urine and fæces. Their conclusions have been embodied in the above volume and in another† more recently issued. The following is but a brief resumé of these investigations:—

The technique adopted by the Commission will be found fully described in the reports. It would be enough for our purpose here to know that the degree of septicæmia was determined at first by sowing neutral broth with dilutions of different strengths of the blood of the patient obtained directly from the vein at the bend of the elbow and calculating from the growth the number of bacilli per c. c. of the blood, and subsequently by enumerating the colonies grown upon sloped dry agar over which 0·1 c. c. of the blood was spread uniformly. Microscopical examination of the blood was also made and animal tests were largely utilised to confirm the results of the above methods. More than one sample of blood was taken from each patient at different periods of the disease and in many instances the urine and fæces were also simultaneously examined for the presence of the bacillus pestis. It was found that a septicæmia existed in 58 % of the cases examined at the Maratha Plague Hospital, and the blood contained from 10 to one million bacilli per c.c. The septicæmic cases have been classified by the Commission into 5 groups according as to whether the colonies which developed from 0·1 c.c. of blood were *very numerous, numerous, fairly numerous, few or none.* The type of septicæmia usually met with was progressive and was most intense immediately prior to death, but not invariably so, as occasionally a fluctuating type was discovered with irregular or disappearing septicæmia. *Very numerous* colonies were found on an average about 19·7 hours before death; *numerous*, 22·6 hours; *fairly numerous*, 85·4; *few*, 105·4; and *none*, 132·5. Microscopical examination was not found to be of much value, inasmuch as it gave positive indications in only 13 cases out of 72 proved to be septicæmic by cultural and other tests. Numerous samples of urine and fæces and soiled linen were investigated simultaneously with the blood, and also independently by various methods. The comparative study of these investigations shows that, whilst in 21 instances culture gave positive indications of the presence of the bacillus pestis in the blood, the urine and fæces gave negative results, indicating that septicæmia need not necessarily be accompanied by the presence of the bacillus pestis in them. Culture and urine both gave positive indications in 18 instances, and in one case the urine was positive whilst culture gave a negative indication. This was probably in a case of fluctuating septicæmia. In one case only (case No. 771) the urine, fæces, culture and the microscope gave positive results. The maximum infectivity of the urine was found to be present within a few hours of death. The blood and fæces of 20 patients were examined and the latter were not infective in 95 per cent. In 16 instances, whilst culture of the blood was positive, the fæces gave negative results. Judging by these results, the urine appears to possess greater infective properties than the fæces. Finally, guinea-pigs were kept in intimate contact in a confined space with the soiled linen and bedding of septicæmic cases, but they failed to contract the disease. The Commission formulated the following conclusions:—

1. A severe septicæmia many be present at a comparatively early stage of the disease, and for a considerable number of hours before death.
2. The degree of septicæmia, as a rule, stands in an inverse relation to the interval before death at which the observation is made, *i.e.*, the shorter the interval before death, the greater the septicæmia.
3. The degree of septicæmia stands in a direct relation to the acuteness of the illness.
4. The septicæmia is usually of a progressive type, but it is occasionally of a "diminishing" "irregular" or "fluctuating" type.
5. A patient with a septicæmia may recover.
6. Microscopical examination of the blood cannot be regarded as a trustworthy index of the degree of septicæmia.

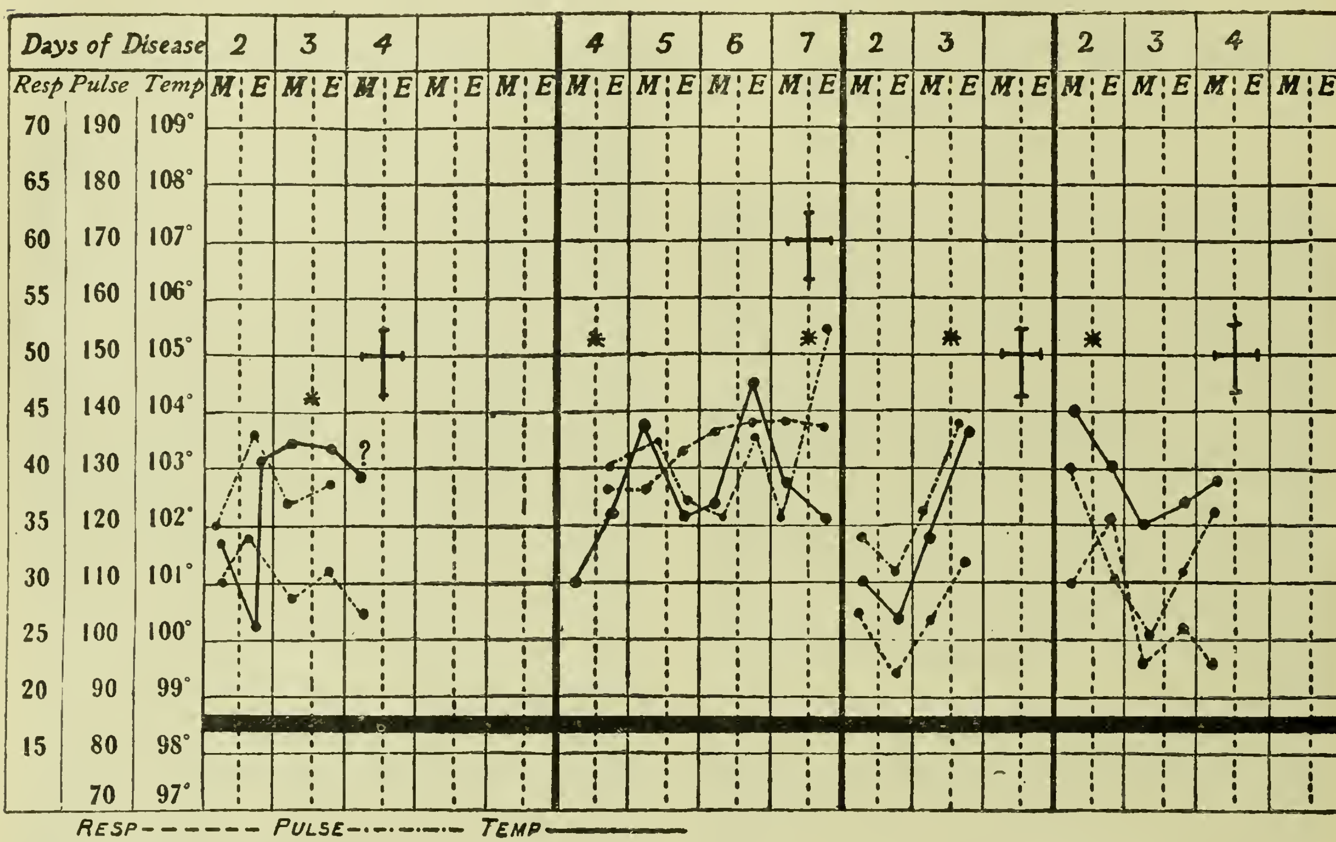
* Report on Plague Investigations in India, First Extra Number of the Journal of Hygiene, September 1906.

† Report on Plague Investigations in India, Fourth Extra Number of the Journal of Hygiene, May 1908.

SERIES A.

Charts of Fatal Cases in which Septicæmia was present in varying degrees.

Case No. 1687. 1677. 1638. 1609.



Case No.	1687.	1677.	1638.	1609.
No. of Pest Bacilli per c. c. of blood	1,000,000.	10,000.	1,000, but not 10,000.	100, but not 1,000.
Hours before death ...	20*	9* to 81*	8*	48*
Microscopical Examination of blood	Fairly numerous.	A few 9 hours before death.	Numerous 8 hours before death.	Negative.

7. The urine of nearly 30 per cent. of the cases in series I and in 19·3 per cent. of series III contained virulent *B. pestis*, which killed test animals when inoculated subcutaneonsly.

8. When the urine proves to be infective by the subcutaneous method of inoculation, its degree of infectivity is directly related to the degree of septicæmia.

9. The maximum infectivity of the urine, as tested by the subcutaneous inoculation with guinea-pigs, appears to occur within a few hours of death.

10. At a particular stage of the disease an absence of infectivity of the urine may co-exist with a severe septicæmia.

11. The urine may be infective although at the time of testing a septicæmia is not present.

12. The experiments devised with the object of testing the infectivity of the excreta from the point of view of the spread of human epidemic support the conclusion that the excreta of plague patients are ineffective in this regard. These experiments show—

(*a*) That the fæces are rarely infective even when a septicæmia is present.

(*b*) That the urine in some cases containing virulent plague bacilli from patients acutely ill of the disease failed to infect guinea-pigs when rubbed into a scarified area of skin.

(*c*) That guinea-pigs exposed to intimate and prolonged contact with linen soiled with the excreta of moribund patients remained free from infection.

II.—CLINICAL FEATURES OF SEPTICÆMIA.

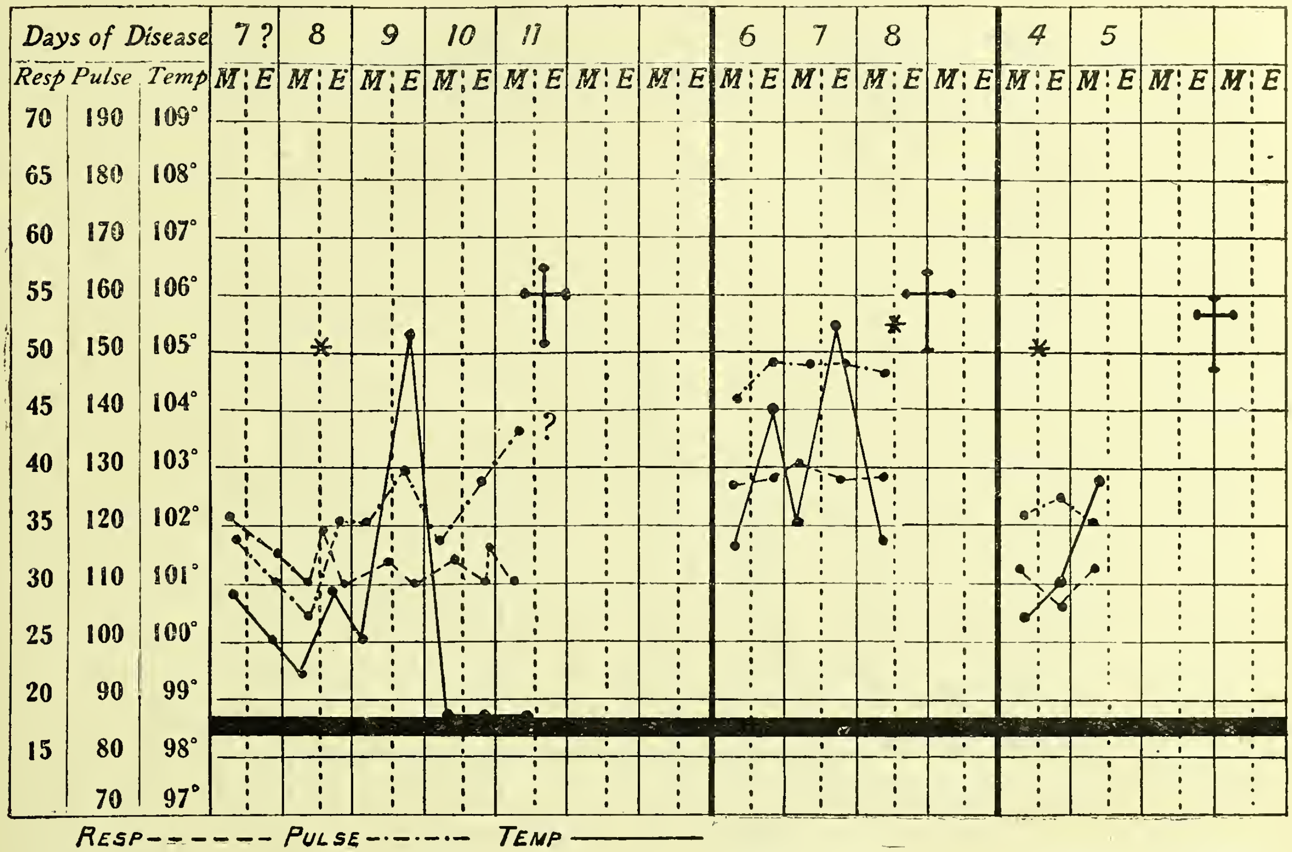
Concurrently with the above investigations, I studied the clinical features of these cases with the view of obtaining therefrom some reliable indications of the presence of septicæmia, that would help us in recognis-

SERIES B.

Charts of Fatal Septicæmic Cases in which there were

I.—Very Numerous Colonies.

Case No.	851.	887.	873.



	851.	887.	873.
Growth on Agar	Good–0·1 c. c.	Layer of isolated Colonies–0·1 c. c.	Very numerous isolated Colonies–0·1 c. c.
Hours before death ...	72*	1½*	23½*
Microscopical Examination of blood...	Negative.	Negative.	Negative.

ing such cases at the bed-side. For after all, it is upon those alone, that we have to rely in every-day practice, as the microscope fails us except only in 17 per cent. of cases of undoubted septicæmia, and facilities for culture of the blood are not always at hand, and, even if available, forty-eight hours are required for a good growth, although in very grave cases, the surface of the agar becomes glazed within twenty-four.

The following is a summary of the clinical features:—

(*a*) All the 72 septicæmic cases, except 2 in whom no apparent buboes could be found, belonged to the bubonic type of plague, and all but 3 proved fatal.

(*b*) There were 6 cases treated with Yersin's Serum (with 2 recoveries), 14 control cases (with 1 recovery), 21 rejected cases (all fatal) eliminated from the above series as unfit for serum-treatment or as controls, and 31 unclassified (all fatal). The aggregate number of serum and control cases (20) was almost equal to those rejected (21). This points to the fact that, whilst it was possible to reject 21 cases as unfit for serum-treatment from their clinical features, there existed an equal number in whom the latter did not afford any help in their prognosis.

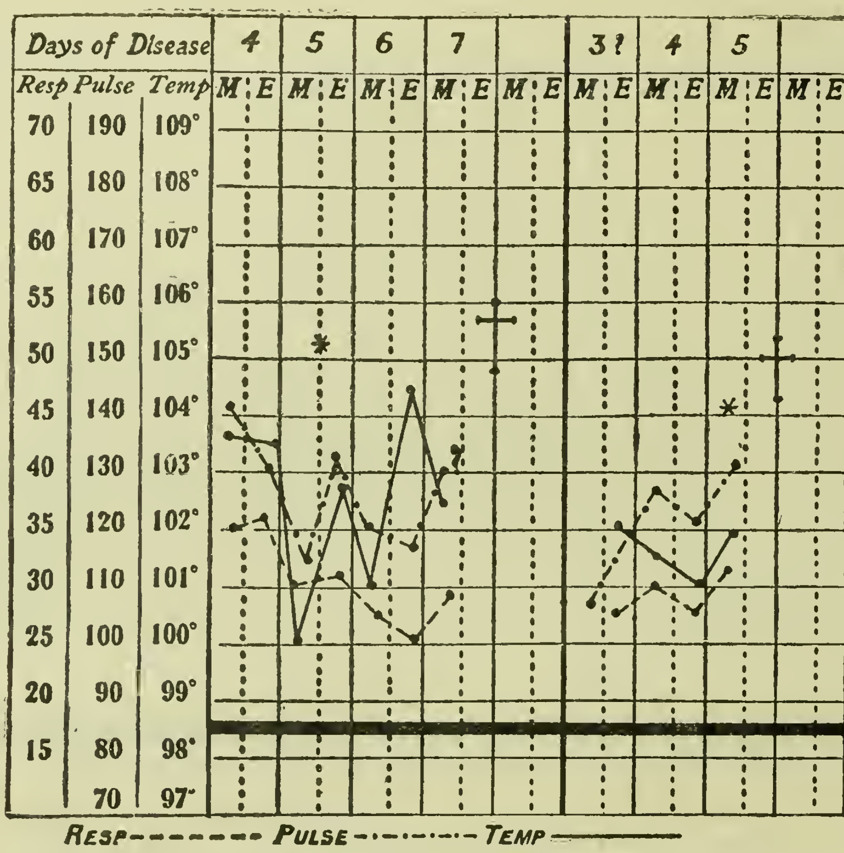
(*c*) The temperature curves, the maximum and minimum temperatures and the numerous and frequent oscillations do not give any clue to the presence of septicæmia. The study of the temperature curve in plague being extremely complicated on account of two or three distinct cycles, the range of temperature in any one or even all of them is practically useless for any guidance. The maximum and minimum temperatures ranged between 103°—105·8° and

SERIES C.

Charts of Fatal Septicæmic Cases in which there were

II.—Numerous Colonies.

Case No. 845. 814.



	845.	814.
Growth on Agar ...	Many isolated Colonies —0·1 c c.	Many isolated colonies —0·1 c. c.
Hours before death ...	43*	2*
Microscopical Examination of blood ...	Negative.	Negative.

98°—101°, respectively; though high, there existed no special features that could be called characteristic, or could distinguish it from numerous nonsepticæmic cases. And, even in the presence of profound septicæmia (as in case No. 1887, where one million plague bacilli were found per 1 c. c. of the blood, the temperature being only 103·40), the temperature alone rendered no assistance. The great irregularity and variability of the temperature in the septicæmia of plague are fully illustrated in the series of charts marked A, B, C, D and E; and, by way of comparison, series F and G illustrate the temperature in nonsepticæmic cases. The charts, besides showing the curves of the temperature, pulse and respiratatory frequency, further indicate (by crosses) the time when the examination of the blood was made, the extent of the septicæmia then present, and the result with the microscope. Cases Nos. 877, 856 and 814 in the septicæmic group, are not very dissimilar to Nos. 1683. 788 and 1589 in the non-septicæmic. The inference to be drawn from the study of the temperature curves is that by the temperature alone, it is not possible to tell whether septicæmia exists or not.

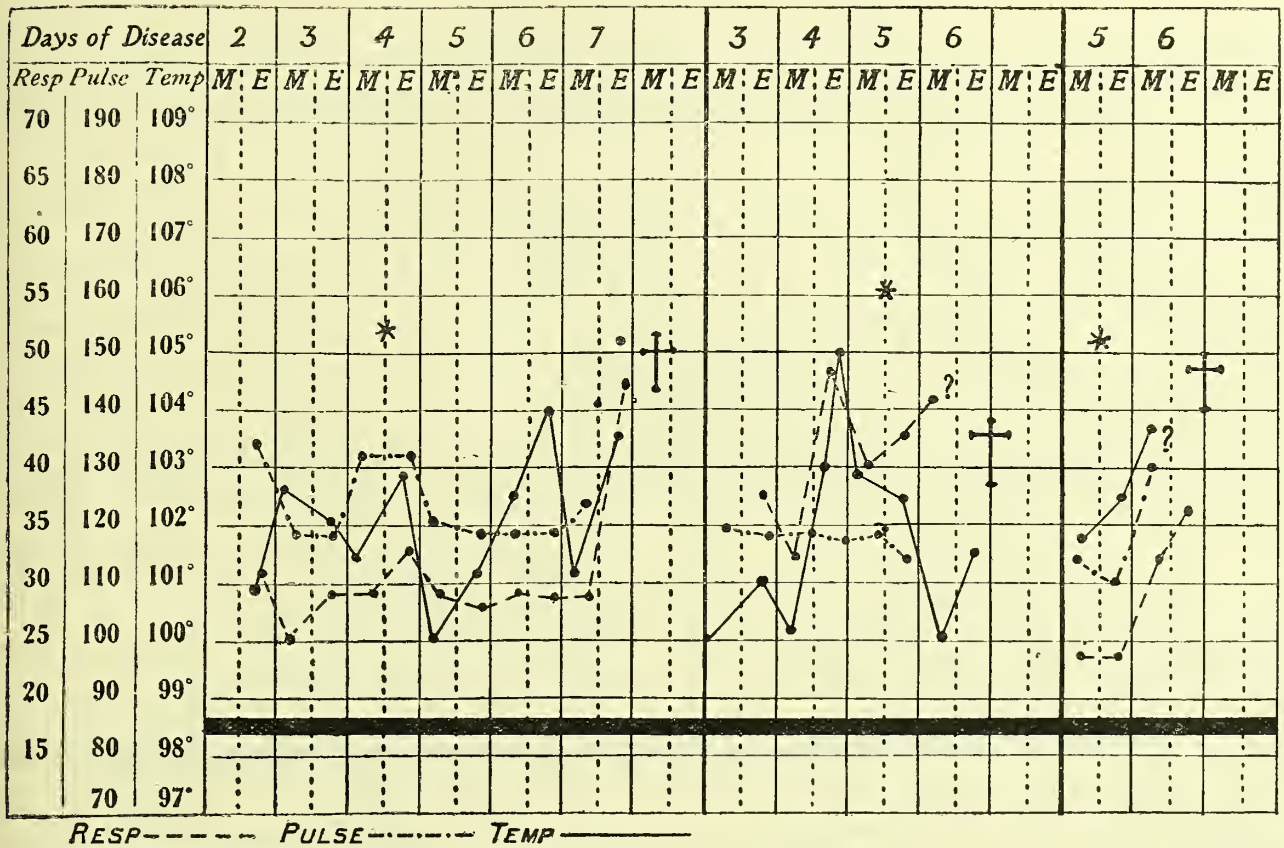
(*d*) In the pulse, however, there is to be found a more helpful guide though not invariably so. Its rythm, regularity, volume and tension are of greater significance than mere frequency. In none of the above charts does the pulse rate exceed much beyond 140 per minute; it is generally under, but almost always the ratio is higher than that of the corresponding temperature. Fre-

Series D.

Charts of Fatal Septicæmic Cases in which there were

III.—Fairly Numerous Colonies.

Case No. 826. 856. 868.



	826.	856.	868.
No. of Pest Bacilli per c. c. of blood ...	500—600	500—600	1,000—2,000
Hours before death	78*	29*	30*
Microscopical Examination of blood ...	Negative.	Negative.	Negative.

quency alone therefore is no criterion of the extent of the cardiovascular paresis, and it is the above characteristics that claim our serious notice. Intermittency of the pulse at regular or irregular intervals, dicrotism, very low tension obliterating the radial pulse at the barest pressure of the finger, partially filled lumen of the artery with or without a beaded pulse, fluttering or almost imperceptible beats or complete obliteration of the pulse at the wrist, are some of the characteristic features met with. But by far the most frequent is the fluttering pulse of very low tension. The myocardium and the vaso-motor mechanism are both at fault, the former from acute degeneration and the latter from paralysis of the inhibitory action of the vagus. No clinical signs can demonstrate on a chart what is felt by the touch of the finger, on which alone we should depend for the purpose. Under these circumstances I had to resort to a sort of rough or arbitrary classification of the pulse as *good, fair, bad, and imperceptible* according to the presence of some or other of the above features. In 10 cases the pulse was *imperceptible* at the wrist; in 42 it was *bad*; in 15 *fair* and in 5 *good*. Thus in 20 cases out of 72 (28 per cent.) the pulse did not lead to an unfavourable prognosis, whilst in 52 cases (72 per cent.) it did so, and these cases were bacteriologically proved to be septicæmic. The character of the pulse therefore raises a strong presumption in favour of the presence of a septicæmia in 72 per cent. of septicæmic cases. *

(*e*) If with such a pulse, there co-exist intense

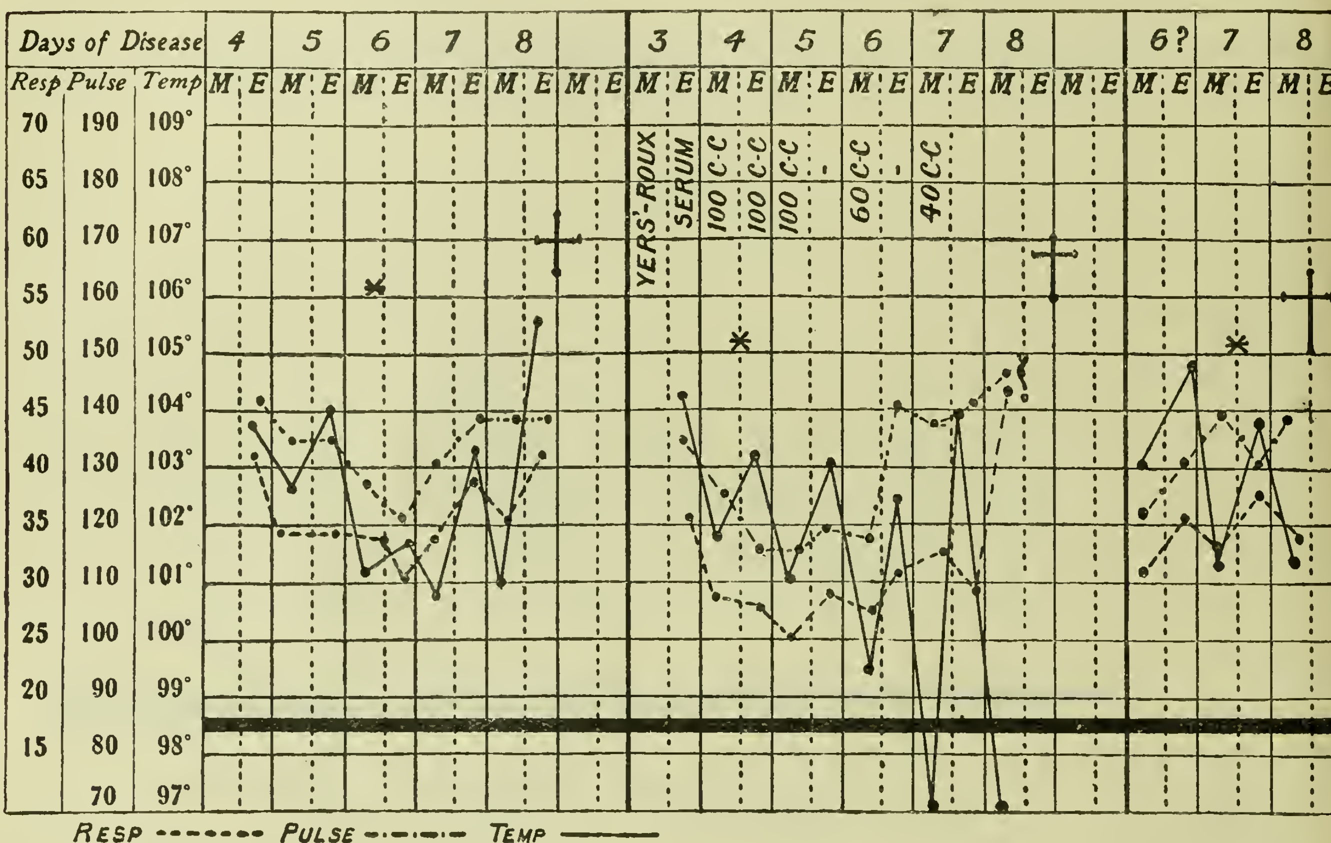
*Cases of sudden cardiac syncope, or those in whom an apparently favourable and good pulse, becomes suddenly bad and imperceptible with rapid failure of heart, have been proved to be septicæmic.

SERIES E.

Charts of Fatal Septicæmic Cases in which there were

IV.—A Few Colonies.

Case No.	877.	859.	886.



	877.	859.	886.
No. of Pest Bacilli per c. c. of blood	100	200—300	300—400
Hours before death ...	54*	91*	25*
Microscopical Examination of blood	Negative.	Negative.	Negative.

nervous prostration with heaviness of limbs, dorsal or lateral decubitus that is resumed no sooner and as often as it is disturbed, with apparent loss of control over the musculature, mental clouding, dulness or great irritability, either jaundice or highly bile-stained urine, and rapid wasting and shrinkage of the muscular and adipose tissues of the face,—if all or some of these are present, there can remain scarcely any doubt as to the presence of a septicæmia.

(*f*) The complications such as coffee-ground vomiting (in 5 cases), terminal pneumonia (in 3), meningeal irritation (in 2), hæmoptysis (in 1), although they do not possess much significance *per sè*, are more numerous than the usual average in all cases, and if present along with the above, further confirm the diagnosis.

(*g*) Primary cutaneous lesions in the shape of bullæ and necroses at the seat of infection were present in 11 cases (15 per cent.)—about double the usual average. The greater risk of septicæmia when these coexist should not be overlooked.

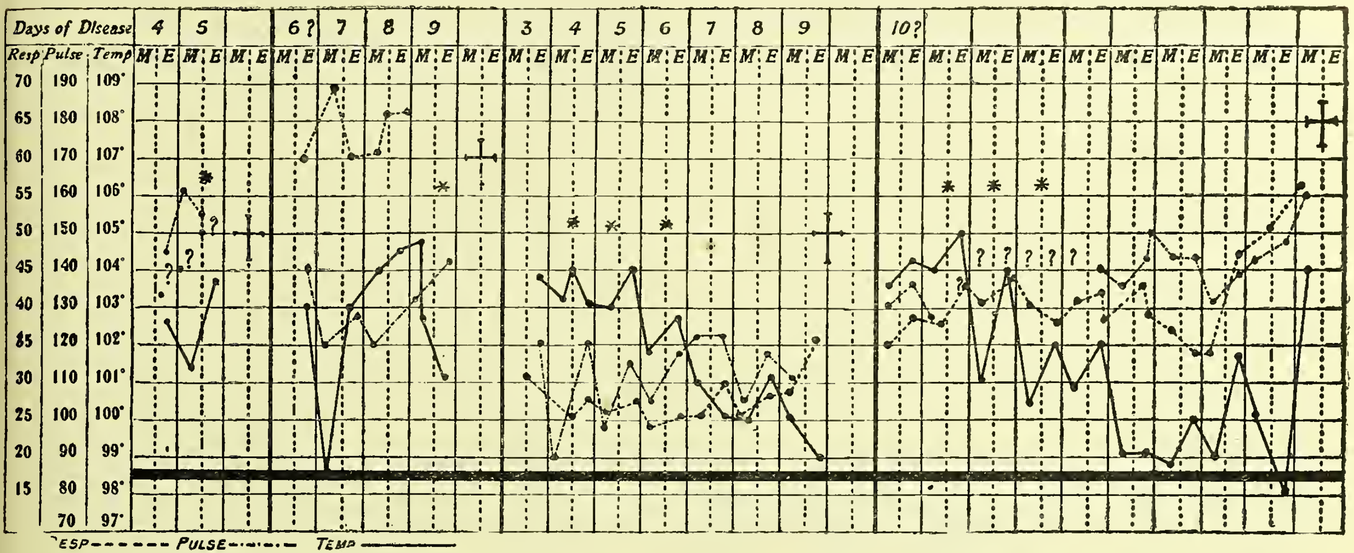
(*h*) The period of illness during which septicæmia is present varies as stated by the Commission, calculating it from the hour of death. If it is estimated according to the duration of illness on admission into hospital after such verification as was possible, it was found that 9 cases were septicæmic on the second day of illness ; 10 on the third, 17 on the fourth, 14 on the fifth, 6 on the sixth,

SERIES F.

Charts of Non-Septicæmic Fatal Cases.

V.—Sterile.

Case No. 872. 788. 822. 819.



Examination of blood made before death (marked *)

4* hours. 15* hours. 79,* 103* and 127* hours. 6,* 7* and 8* days.

7 on the seventh, and 3 on the eighth. This implies that by far the larger proportion is found within the fifth day of illness, which is corroborated by the mortality in the following para.

(*i*) Although it is possible for a septicæmic case to survive up to the 30th day of illness, it is the exception rather than the rule. About 75 per cent. of the cases succumb by the 6th day of illness, 20 per cent. more by the 11th and 5 per cent. by the 20th; 85·5 per cent. of all deaths among septicæmic cases occur within four days of admission into the Hospital and only 14·5 per cent. thereafter.

(*j*) Recovery in septicæmic cases is possible. The Plague Research Commission say that a patient with a septicæmia may recover and 3 recoveries have been recorded by them in 72 cases (about 4·2 per cent.); Greig estimated that the recovery rate was only 3 per cent. It may therefore be assumed that 3 to 4 septicæmic cases recover out of every 100. Among the 3 recovered cases above recorded, in one there existed 500-600 colonies per c.c. of the blood; in the other 10 colonies, and 20 to 30 in the third. The last was a control case,—chart of case No. 314. It presents no special features beyond a somewhat prolonged course of two weeks. When septicæmia is so moderate, the toxæmia from bacteriolysis, does not fully develop into marasmus, although there may be some wasting, slight icterus and great prostration. It is probable that the septicæmic cases that recover without the administration of an anti-plague serum are of this nature.

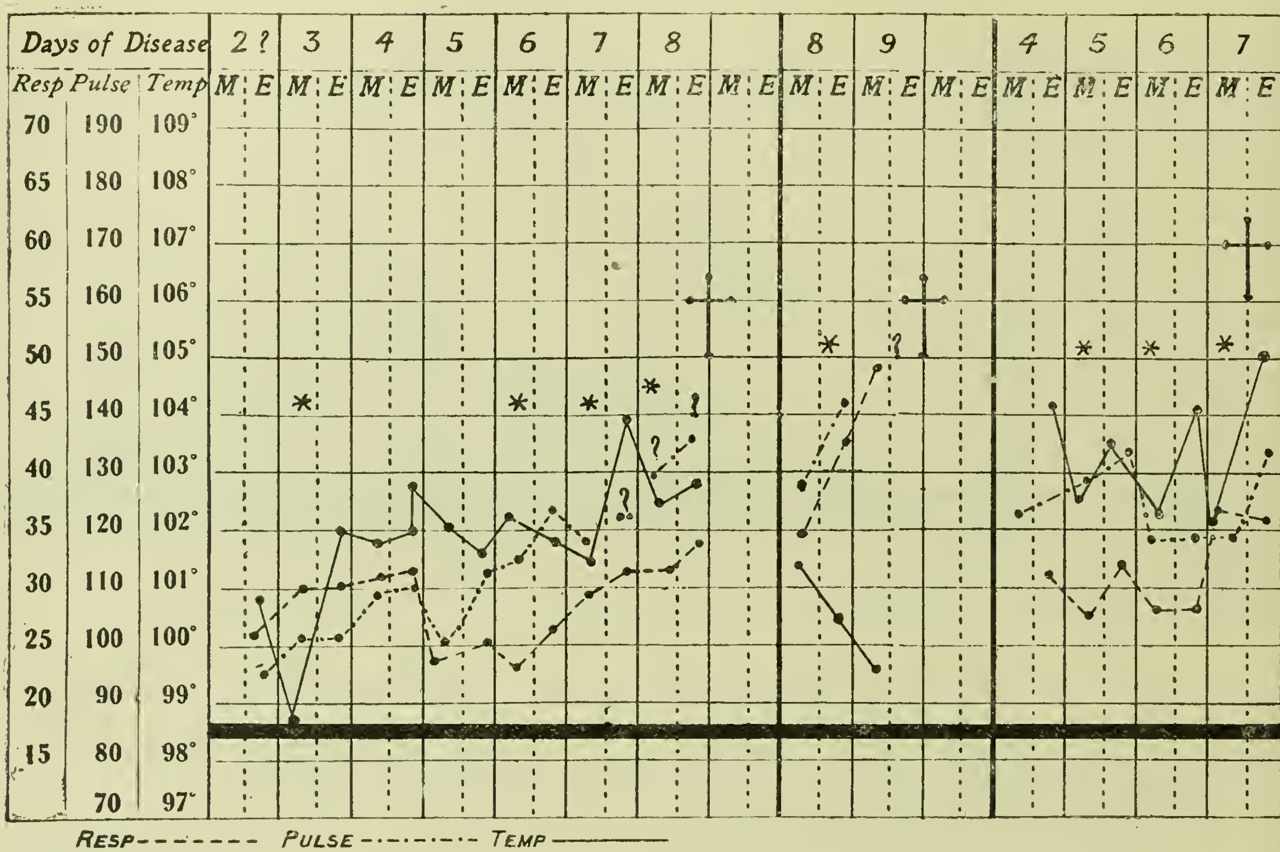
The other two cases were treated with Yersin's serum. In case No. 866 whose chart is appended, the patient was a male child aged about 7 years, with a bubo in the right axilla. The blood examined on the second day of illness indicated the presence of 500—600 colonies per c.c. It was subjected to the serum treatment on the same day and received 270 c.c. of the serum in six injections. The bubo suppurated and was incised on the seventh day of illness. The little patient developed subacute marasmus from the ninth day characterised by great prostration and wasting, glosso labio-pharyngeal paresis, polyneurites and the train of symptoms that I have fully described elsewhere.† The chart exhibits the temperature curve and records of pulse and respirations together with the prolonged course of illness, which ultimately ended in recovery. The gravity of the septicæmia coupled with the large quantity of serum injected, 270 c. c., looking to the age and size of the patient leads me to infer that but for

† Serum-Therapy of Plague in India by the author 1907, pp. 31—32.

SERIES G.

Charts of Non-Septicæmic Fatal Cases.

Case No. 1585. 1589. 1683.



Examination of blood made before death (marked*)... 12½*, 36½*, 60½*, and 132½* hours. 27* hours. 17*, 41* and 65* hours.

the application of the serum the patient would not have recovered.

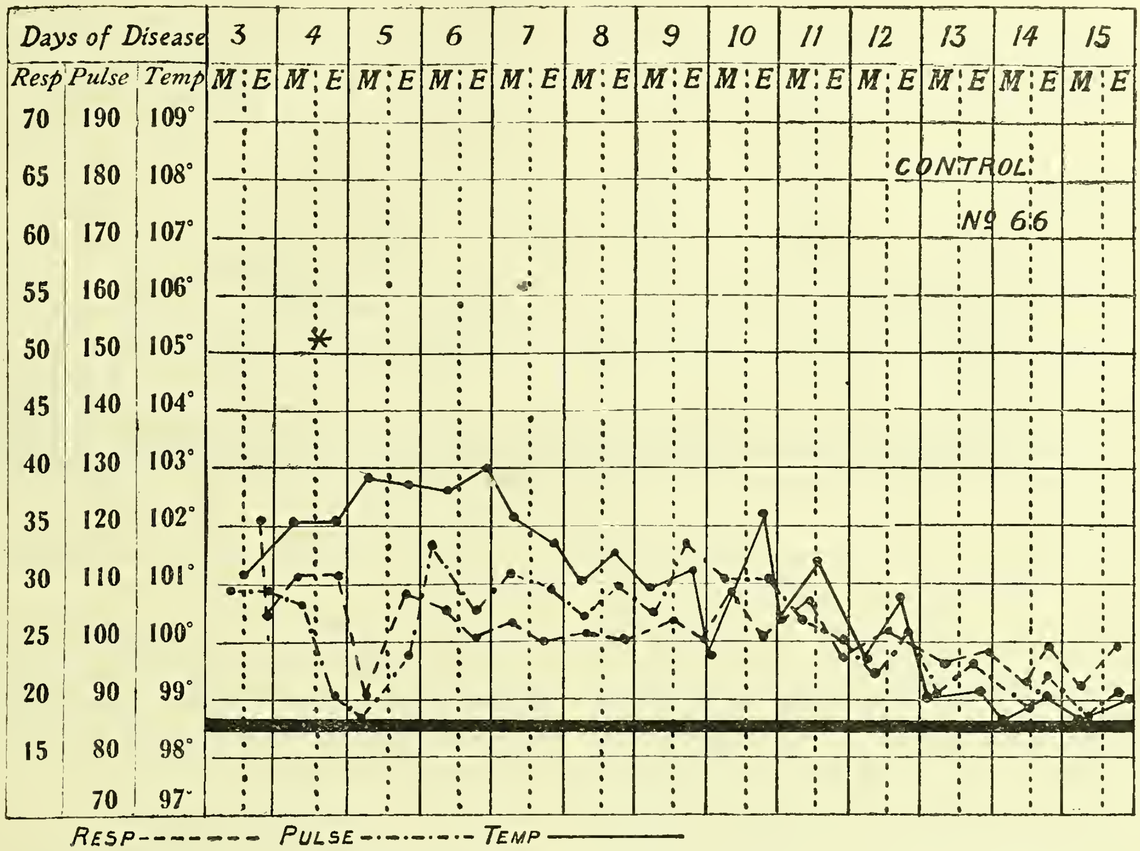
Case No. 869 was less grave, a female aged 25, with bubo in the right axilla. She had six injections of serum aggregating 420 c. c. and she too recovered after a rather prolonged illness, after going through subacute marasmus.

(*k*) Septicæmic cases with moderate septicæmia develop a peculiar train of clinical phenomena, if they survive over a week, and especially with greater frequency in those subjected to the serum treatment. These are the direct result of the bacteriolysis brought about either by the action of the anti-plague serum or by the natural immunising substances produced in the blood. A large amount of toxin is suddenly poured into the circulation and before it could be neutralised or eliminated it enters into combination with the tissue-cells of tho body and produces profound toxæmia which is recognised as plague marasmus.

It occurs in two forms, the acute and the sub-acute, and shows itself about the time the patient is getting apparently better—about the eighth or tenth day. Considerable improvement in his general condition, the pulse and temperature almost normal, the bubo either small, hard and getting gradually absorbed or just suppurating and the body free from living plague germs, are the antecedent conditions. In the course of a day or so, or even during a single night, a sudden change is noticeable in the patient. The face becomes pinched and hollowed out from rapid wasting and shrinkage of the adipose and muscular tissues; the bones and prominences start out from the face, the eye-balls sink, the look becomes vacant, and he lapses into a condition of semi-stupor from which he can be roused with difficulty. Speech becomes inaudible and reduced to a whisper, the patient moans occasionally and does not like to be disturbed. The decubitus is dorsal. The pulse, a few hours before so hopeful, becomes thready and the extre-

Chart of a Septicæmic Case which Recovered without Serum Treatment.

Case No. 314.



20-30 Colonies per c. c. of blood were found on the fourth day* of illness. Good recovery without suppuration of buboes.

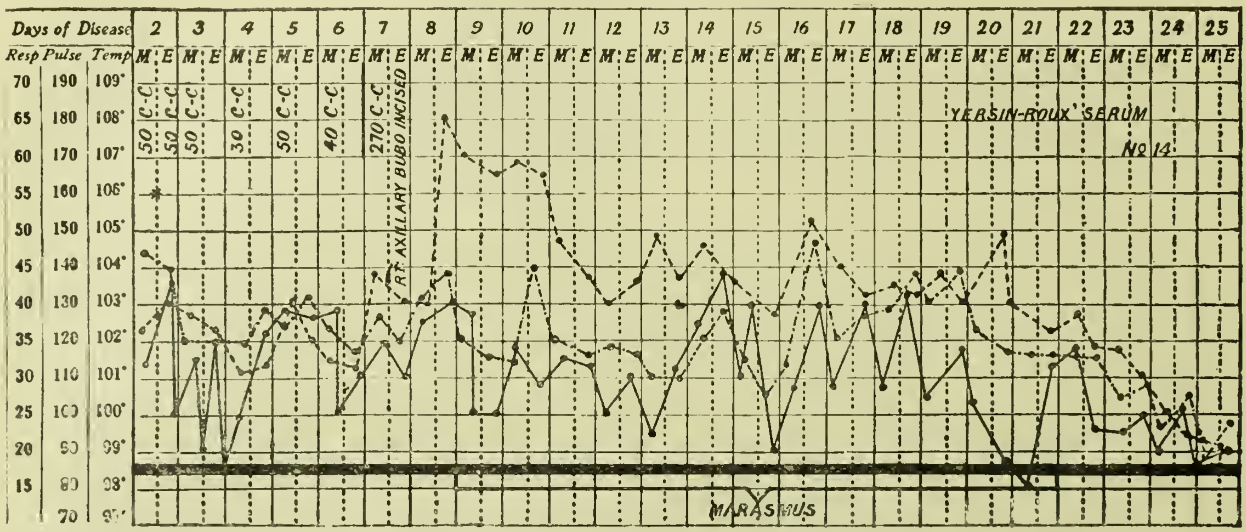
mities cold. There is great prostration and general heavy condition of the limbs, which become leaden, and paresis of the muscles of deglutition may supervene making feeding difficult. Simultaneously with the above symptoms the body becomes intensely icteric. The conjunctiva and nails become yellow, the skin of the same hue and excretions highly charged with bile. There is not much rise of temperature unless there exists some secondary infection or deep suppuration. The patient remains in this condition for a day or two and then the stupor becomes intensified, the pulse weaker and weaker, the wasting increasing considerably till the extremities and trunk are involved. The reflexes are abolished, glosso-labio-pharyngeal paralysis sets in and so also polyneuritis, if life is prolonged. The cornea becomes glazed and either keratitis or panophthalmitis result. The decubitus may now become lateral with the knees drawn up and the legs fixed over them. The temperature steadily rises and when death supervenes within six to eight days from the onset of the above symptoms it may be as high as 106°—107°. In some cases the temperature remains subnormal until death. All these symptoms indicate profound intoxication of the system. There are three times as many cases of marasmus among those treated with the serum as in those without, and it is but a logical sequence of the use of the serum. For, whilst nature unaided can produce disintegration of the bacilli in only a few of the grave cases, serum does so in a larger proportion.

The same phenomena are observed in cases not treated with the serum, but, as stated above, in lesser proportion and they supervene if a large or even moderately sized bubo gets rapidly absorbed and disappears within a day or two, thus surcharging the system with the liberated toxin. All cases of acute marasmus end in death.

In the sub-acute form, the above symptoms exist, but they develop very gradually after about a fortnight's illness and last much longer. Whilst in the acute form the patient dies within the third week of illness, the sub-acute may extend to over six, eight or even ten weeks. The condition of the patient is then extremely pitiable. The wasting progresses over the whole body, all the flesh practically melts away and the patient is reduced to a mere skeleton. Trophic changes in the eye supervene and sight may be totally lost through

Chart of a Septicæmic Case with Fairly Numerous Colonies which Recovered under Serum Treatment.

Case No. 866.



500-600 Colonies per c. c. of blood on the second day of illness * Patient received six injections of serum aggregating 270 c. c. Subacute marasmus; great wasting; tardy but good recovery.

panophthalmitis; as also in the bones and joints which swell ; ulcers and bed-sores form in spite of every care and attention; the power of speech and deglutition may be completely lost. The reflexes are abolished; the urine and fæces are voided involuntarily; the saliva dribbles from the angles of the mouth and, as the secretions of the throat and lungs cannot be expelled, they accumulate in the throat and almost choke the patient. Glosso-labio-pharingeal paralysis and polyneuritis supervene. The muscles become contracted, and every moment becomes painful. The patient lies doubled up—a dull, shapeless, wasted being, there is no adequate response to even strong stimuli and all that he can express in reply to calls is a groan or whine, unintelligible and scarcely human. At times there is a vacant stare in the eye but there is no recognition. He can hardly be said to live, but exists, until merciful nature comes to his aid and ends the misery. Here and there a recovery may be possible, but almost all such cases end in death. Convalescence is extremely prolonged and it may take four to six months before the patient can move about. In other instances the after-effects last for years, and the patient is never himself again as defects in speech and power of mobility become almost permanent.

Between these two forms of marasmus, there exist a few cases that may be said to be on the border line. They appear to be about to merge into it when improvement sets in and they recover, though recovery is tardy. In such instances the toxæmic condition is just enough for the system to cope with and no more.

CONCLUSIONS.

1. There exists no single clinical sign or symptom whereby the presence of a septicæmia can be recognised at the bed-side.

2. A strong presumption of septicæmia is raised by a thready, compressible or imperceptible pulse, especially if accompanied with great nervous prostration, jaundice and rapid wasting of the face.

3. Although a patient with a septicæmia may recover, the probability of recovery is only 3—4 per cent.; no recovery with a grave septicæmia is possible; and, even with a moderate one, recovery would be greatly helped by the use of the anti-plague serum.

4. Plague marasmus is an almost invariable concomittant in those cases that survive over a week; if acute, it is always fatal, if sub-acute, recovery may take place.

THE PROPHYLAXIS OF PLAGUE.

By Captain W. GLEN LISTON M.D., D.P.H., I.M.S.

Member of the Plague Research Commission.

Introduction.

In introducing the discussion on the prophylaxis of plague I do not propose to deal with the whole subject, that would be a difficult task since it would involve not only a discussion of the best means for checking the spread of plague in an infected country but also a consideration of the measures which are necessary for the safeguarding of continents and nations which, for the time being, are free from the ravages of the pest. On the present occasion I propose to confine myself to that part of the subject which concerns the prevention and suppression of plague in a country already infected, and I shall further limit the discussion to a consideration of the measures applicable to a country like India. For our present purpose India may be described as a vast continent, densely populated with a poor, ill educated, cosmopolitan community, ignorant of the very elements of European sanitary organization, replete with religious prejudices, but withal a people who can be easily led.

While I have thus limited the scope of the present discussion, I wish to define my claims for speaking on this subject. At the outset I must confess that the views and opinions which I propose to place before you have not been tested by an extensive practical experience of their applicability to the conditions which confront us in India. Nor could they well have been so tested since they are based on the most recent scientific study of the ætiology of this disease, on facts which, within the last two or three years, have completely revolutionised our notions of how the plague is spread. My views, however, are based on an intimate acquaintance with plague during the last ten years, both in the laboratory and in the field. The study of the disease, moreover, has not been trammelled by any responsibility for checking it, so that my views as to how this may best be accomplished have not been warped by adherence to any party policy. I am in a position to regard the subject as it has been revealed by a study of the ætiology of the disease, not as shown by the process of trial and error, by failure or success in the practical application of the general principles which guide the sanitarian in the prevention of infectious diseases.

This position, though it lacks the support of practical experience, has at least the advantage that it is based on a fuller knowledge of the disease, a knowledge which enables us to distinguish plague from other infectious diseases, and which therefore calls for special methods for preventing and suppressing it.

Preventive measures must be based on a knowledge of the ætiology of the disease.

All rational methods for the prevention of diseases depend on the views which are held concerning their ætiology. I must, therefore, declare my position in this respect.

The ætiology of plague has already been discussed and has been dealt with at length by Major Lamb with whose opinions, as expressed in his paper, I entirely agree. I need only, therefore, here summarise what I believe to be the salient features of this view of the ætiology of plague by condensing them in the following definition of the disease.

Definition of Plague.

Plague is a disease caused by the presence of the plague bacillus in the blood or tissues of infected animals. The bacillus is a parasitic organism which is transferred from the blood of infected animals to the blood of healthy ones, chiefly by means of the rat-flea, *Lœmopsylla cheopis*. The bacilli are capable of effecting a lodgment in the stomach of this species of flea in particular, and are able to live and multiply in the body of the flea for at least some days. In this situation the bacilli are protected, and can avoid the struggle for existence with the innumerable saprophytic bacteria which abound in nature, and which would soon displace the parasitic plague microbe where it entered into competition with them. For the reason that *Lœmopsylla cheopis* is, for the most part, a parasite on rats, the disease especially affects these animals, men generally participate in the infection more or less as they come in contact with rats. It is, however, by human agency that rat-fleas and especially infected rat-fleas are carried from the rats of one locality to those of another. The disease shows a well marked seasonal prevalence so that, in any place, the number of infected centres during the quiescent period becomes comparatively small.

Plague is essentially a rat disease.

Plague may be compared with Hydrophobia, Glanders and Anthrax in the respect that, like these diseases, it is essentially an animal disease, the infection is occasionally communicated to man almost as it were by accident and only when he comes in direct relation to the particular animals infected in each case. Experience has shown that the spread of the above mentioned diseases among men can be effectually controlled by curtailing the spread of the disease among the particular animals which suffer, dogs in the case of Hydrophobia, horses in the case of Glanders and horned cattle in the case of Anthrax. So also the prevention of plague resolves itself into the prevention of plague among rats. This is the fundamental principle on which all plague prophylactic measures should be based. I propose now to consider how this can best be accomplished.

The prevalence of the disease among rats depends largely on their numbers so that indirectly the conditions which favour the multiplication of rats conduce to the development of plague.

The prevalence of plague among rats to a large extent depends on the density of the rat population. There are three essential conditions which encourage the presence of rats. These are :—

(1) Abundant food,
(2) Ample shelter,
(3) Absence of enemies.

With this knowledge we are in a position to devise means for the reduction of the rat population and so indirectly affect the prevalence of plague among these animals. The abatement of the conditions which favour the presence of rats becomes thus the first line of our defence against plague. Let me consider each of the conditions separately which conduce to the multiplication of rats and see how far measures can be taken to abate them.

Abundant food supply as a condition encouraging the presence of rats.

An abundant food supply for rats can be easily found in every town and village in India. Almost every householder maintains for his daily use a large stock of grain stored, generally for a long period, in some earthen or straw receptacle which can be readily penetrated by rats. No attempt is made to centralise these stocks of grain or isolate them in particular parts of the town or village. It must be admitted, however, that a certain amount of care is taken by each house-holder to limit the predation of rats on his grain but he is quite callous as to how the household refuse is disposed off. Each man is a law unto himself in this matter. There is certainly no satisfactory, if any system at all, for scavenging in the villages. The majority of the towns are not much better in this respect. It thus comes about that in and around every Indian dwelling rats are able to find an abundant food supply.

A proper system of scavenging is the A, B, C of sanitary administration, while water works, drainage schemes, etc., are to it as learned books which the people are often called upon to master before they have acquired the alphabet. Greater attention to the organisation of systems for the removal of refuse from towns and villages will be the first effective blow struck at the ubiquitous Indian rat.

Shelter as a condition favourable for rats.

Secondly, ample shelter is afforded for rats in the construction of Indian dwellings, and the presence of these creatures in the houses is further encouraged by the habits of the people in living with their cattle, and in collecting and storing all manner of articles, which are seldom used or turned over, and among which rats find a comfortable home. The removal of these defects can be accomplished but slowly, yet, because time will be required to see the fruit of this good work, it is not necessary to neglect it altogether.

Defects in village and town planning.

An Indian village is generally constructed on a plan which was devised in the days when no man knew when marauding bands would swoop down on his household. The houses in an Indian village, therefore, are huddled together, none of them open into the fields, all face towards the interior of the village, the object being to present a blank wall around the outside of the village, and to allow of approach to the houses only by easily defended narrow lanes.

British rule has now been established in India for more than fifty years; law and order prevail; but the villages remain as they were constructed, when each had to defend itself against invasion. New villages are arising in the canal colonies, which are built on the old plan, although the conditions which necessitated this scheme of construction have long ceased to exist, and are not likely to arise in the future. Can nothing be done to improve this state of matters? I have referred to the villages, but in the towns, schemes for the future development of them have seldom been considered. They enlarge, with few exceptions, in a haphazard fashion. The advent of plague has, however, led to the founding of Improvement Trusts in some of the large cities. These Trusts have been instituted with the object of carrying out schemes of improvement and development. Unfortunately, they have been brought into being when the cost of effecting improvements has become enormous. While Trusts have been established in the cities, little has yet been done to deal in a similar, though smaller way, with the towns. A conspicuous exception in this regard is perhaps to be found in the case of the towns situated in the United Provinces.

Defects in the Enforcement of Building Regulations.

Apart from these larger schemes, much can be done, on a smaller scale, in the proper enforcement of building regulations. In many cases the machinery exists but the law cannot be enforced, either because the magistrates are inclined to take a lenient view of the shortcomings of the people, or the law is interpreted according to the letter and not the spirit. Something at all events must be radically wrong with the building regulations when disused tramcars can be placed by the side of one of (Parel Road) the chief thoroughfares of a city like Bombay, and be used with impunity as shops and even dwelling houses.

The Stabling of Cattle in Dwelling Houses.

I have already mentioned the dangerous habit so common among the people of India of living together with their domestic animals, cattle, goats, hens, etc. It will be a difficult problem to discourage this habit in the villages, especially those situated in the jungle, but to tolerate it in the towns seems to me to be neglecting the first principles of sanitary reform. When these faults are remedied, the second effective blow will be dealt at the so-called rat problem.

The absence of Natural Enemies encourages the presence of Rats.

Thirdly, the absence of natural enemies permits of the multiplication of rats. Now in civilised countries the greatest enemy of the rat is man. In this country man is the rat's friend and supporter. In Europe he is regarded as a thief; here he is a dependant, deserving to be fed. Education alone can improve this imperfection; it is one, however, which can to some extent be overlooked, especially if the presence of other rat enemies is encouraged. By all means let us advocate the keeping of cats, but this cannot be regarded as the beginning and end of plague administration, as some would have us believe.

In the absence of opportunity for improving the conditions which favour rats then the removal of them must be accomplished in some other way.

When the conditions which afford food and shelter for rats and which allow them to increase and multiply in undisturbed peace have been banished, permanent and

effective progress will have been made in diminishing their number and thus eradicating the plague. But, as is evident from the magnitude of the necessary operations in this country, we may be compelled to seek other more rapid, though perhaps less effectual and less permanent, methods to rid ourselves of these pests. There seems one way only to accomplish this. If we are unable to out-manœuvre the rats by the flanking movements I have described above, we must be prepared to make a direct frontal attack on them. If we do undertake this, we must bear in mind that we are not able to take advantage of the natural lie of the land, but are riding roughshod over it, so that to effect our object we must make a very special effort. We must remember first that the number of rats present in Indian houses is often very large, and secondly that the fecundity of the rat is enormous, in short the strength of the enemy is great and his resources unlimited.

Systematic Rat-trapping as a Method for destroying Rats.

Experiments conducted by the Plague Commission and others have shown that in the conditions found in this country, if success is to attend measures of rat destruction, it is necessary to remove in the course of a single year a larger number of rats than is represented by the human population of a town or village. Experience has demonstrated that the most satisfactory way to directly diminish the number of rats in a village is to set a large number of traps systematically. Much depends on the thoroughness and system of the operations. I cannot here fully enter into this subject, perhaps others will consider it, but I may say that a number of traps, equivalent to at least 2 per cent. of the population, must be used. The traps should be regularly and carefully set, and precise notes kept as to where the rats have been caught. Working in this orderly way, it is possible to find out where rats abound and what conditions favour their presence. in short we make a careful study of the rats. It is then only necessary to take in hand the improvement of the rat-infested premises; such a place, in a plague-infected country, should legally be considered a nuisance, and the owner should be called upon to abate the nuisance. In thus combining our frontal attack with flanking movements we will best be able, as in war, to bring about the discomfiture of the enemy.

Rat destruction generally fails, because the extent of the operations is not always properly gauged.

In concluding the consideration of this part of the subject, I must emphasize the fact that often those who undertake rat destruction have little idea of the magnitude of the task. Many attribute this failure in preventing the spread of plague to the uselessness of the measure, disregarding the fact that the organisation and thoroughness of their operations have been defective, not the principle on which they were based.

Importation of Infection, the chief means by which the disease is spread from place to place.

Rats can only do harm, so far as plague is concerned, when they become infected. We know that infection is carried from the rats of one place to those of another by human agency. Starved and infected rat-fleas, deprived of their natural hosts which have been destroyed by the plague, take to man. Infected fleas are thus carried in the clothing and kit of fugitives from plague-infected houses to healthy localities. Here again, the fleas brought in propinquity to rats take to these animals in preference to their temporary human host. In this way the rats become infected and further spread the disease. Importation of infection in this way is the chief, if not the only way, in which towns and villages become infected.

Disinfection of Clothing and Kit of Travellers is an important plague measure.

It is necessary, therefore, to take measures against this important means by which infection is spread. The prevention of the importation of infection from infected places to healthy towns and villages is our second line of defence against plague. Disinfection of the clothing and kit of persons coming from infected places is a very necessary, though now neglected, measure. The comparative success of the prevention of the spread of plague over sea can, no doubt, to a large extent, be attributed to this precaution. As a means for preventing the spread of plague on land it has been abandoned, mainly because, in practice, it has been shown to be not quite perfect. This seems to be a poor argument for discontinuing so necessary a safeguard. The spread of plague is largely a matter of chance depending as it does on this method of importing infection. If even some of the opportunities for carrying infection to uninfected places are prevented by disinfecting the clothing and kit of travellers it is surely better to adopt this measure than to abandon it altogether especially as each successful importation of infection, means the development of disease among rats and consequently many cases among men. As another reason for discontinuing the disinfection of the clothing of travellers, the expense of the measure has been urged. I hope to show, that there are other measures on which large sums of money are being expended, which, compared with this one, in the light of our new knowledge, are comparatively useless, and which, with advantage, might be abandoned in favour of it. I refer to such measures as the isolation and treatment of the sick in hospitals, the disinfection of infected houses, and evacuation as generally practised. To mention these measures is sufficient to indicate the large sums of money which would be at our disposal if they were abandoned.

The Prevention of the Importation of Infection can be carried out with the best hope of success at the close of the active plague period.

The prevention of the importation of infection presents insuperable difficulties to many. They point to the very large number of infected centres to be found during the active plague period, they forget that the number of these centres becomes greatly reduced during the quiescent

period. It is during this period that the disease can most easily be tackled; yet it is generally the period chosen for holidays, the period when efforts at stamping out the disease, as it has been called, are brought to a standstill. Fear has departed and the stimulus for work has gone. No greater mistake could be made than to curtail operations and expenditure at this time. It is the period which offers the greatest hope of success.

A well-organised scheme of intelligence is essential to the successful carrying out of this measure.

An extensive and well-organised scheme of intelligence is essential to the thorough working of this measure—the prevention of the importation of infection. It is lamentable to think that in some parts of India information about the presence of plague in the districts often takes days and even weeks to reach the head of the sanitary administration. There can be no doubt that it is possible to get the information earlier, for means at present exist for the speedy reporting of attacks of cholera and small-pox, but to my knowledge no scheme of this sort for plague registration has been devised in at least some of the provinces. Not only should information be available of the presence of the diseases among men, but a close watch should be kept on the appearance of infection among rats. Surveillance of travellers, in the sense of observing whether they develop the disease or not, might well be abandoned in favour of the disinfection of their clothing and the adoption of a system for rapid and wide registration of infected places. Villagers should be encouraged in every way to prevent persons entering their village from infected areas until they have taken care to rid their clothing and kit of infected fleas.

Permanent and temporary centres of plague infection.

There is one more point to accentuate in connection with this subject; it is this, that there are permanent and temporary centres of infection. The cities are the chief permanent centres of plague. In Bombay city for example, the Plague Commission has shown that every day throughout the year a plague infected rat may be found in some part of the city. The large cities, therefore, may be regarded for the time being as endemic centres of the disease and every effort should be made to eradicate it from them.

Attempts in the past to eradicate the disease from permanent centres were unsuccessful, because the manner in which the disease is spread was then unknown.

It is true that an attempt in this direction was made in the case of Bombay when the present epidemic first appeared in India. Money then flowed like water in a convulsive endeavour to abolish the disease. Medical experts, sanitarians, and military organisers were given a free hand by the administration. But it was a case of the blind leading the blind. Ten years of experience of the disease, and above all ten years of patient scientific study, has cast a very different aspect on the problem. The scales have fallen from our eyes; we now see how we should proceed, although the road we may have to tread is a very difficult one; the vision at least is better than the darkness that then surrounded us. We are not likely again to be led along side-paths or asked to squander our money to no purpose; it may yet, however, take some time before we all find our way back to the straight road and realise that many of the measures we still cling to are not as good as others which, in our confusion, we have abandoned. The only danger is that we should meantime despair. There is very good reason to believe that already we have become fainthearted. The annual expenditure on plague measures in Bombay City, for example, has fallen from more than 12 lakhs to something under two. It is time we took courage again and now, with open eyes, endeavoured to purge this fair city of the blight which has spread and still continues to spread from it over India.

The temporary centres of infection, during the quiescent period, vary from year to year. They are more difficult to locate than the permanent centres, but they also require attention. A thorough intelligence system will help us to mark them down. When found, they will be more easily dealt with than the permanent centres in the cities.

Inoculation is our third and last line of defence.

Lastly, when we have been unable to remove the causes which conduce to the presence of rats, and have been unsuccessful in diminishing their numbers by a direct attack upon them, and again have failed in our second line of defence, the prevention of the importation of infection by human agency, we have to fall back on our third and last line of defence. We must be prepared to withstand the plague attack, at the point of the bayonet as it were, by rapidly acquiring immunity against the disease. This can be readily done by inoculating the threatened people with anti-plague vaccine, Haffkine's prophylactic. There can now be no question of the efficiency of this method of combating the disease. It is cheap, it is easy, but of course not perfect. We must be prepared to lose some in the fight, but a guarantee can be given that at least six times as many lives will be saved by the adoption of this armour as would be saved without it.

Measures of doubtful expediency.

I now come to consider certain other expedients which have been advocated as effective plague measures but which I consider to be less useful and less necessary than those mentioned above. The measures I refer to are isolation and treatment of the sick in hospitals, disinfection of plague-infected houses and evacuation as generally practised.

Isolation and Treatment of the Sick in Hospitals.

Let me deal first with isolation and treatment of the sick in hospitals. This measure has been adopted for two reasons (1) to prevent infection being communicated from the sick to the healthy, (2) to secure better treatment for the sick. The relation of the human

plague case to the spread of the epidemic has been dealt with by Major Lamb in his paper; he has shown that the human plague case plays little part in the spread of the epidemic. Again, the treatment of plague is still in a very unsatisfactory state; there is no specific remedy. Indeed it is questionable whether the advantage of the more efficient treatment obtained in hospitals is not compensated for, perhaps overcompensated for, by the dangers associated with the removal of a patient to the hospital. The arguments, therefore, for adopting this measure are without foundation.

Disinfection of Plague-infected houses.

Secondly, let me consider disinfection as a plague measure. The object of disinfecting plague-infected houses is to destroy the infection in them. It has been shown that the infection in houses resides, not on the floors, as was once believed, but in the bodies of infected rats and their fleas, and any disinfecting process must aim at the destruction of these vermin. No suitable disinfectant has yet been discovered which is capable of accomplishing this object in the circumstances we find in India. It can only be advantageous to kill fleas by the use of pulicides in exceptional cases since the methods generally in vogue seldom affect the fleas which are to be found on the bodies of rats or in the rat holes and haunts. Infection from these sources, therefore, can easily be reintroduced into a room after it has once been disinfected. The energy and money expended on disinfection might well be appropriated for some more effective measure.

Evacuation.

Lastly, a word will suffice on evacuation. This measure when properly carried out is a very expensive one and requires much supervision. When improperly adopted it is a worthless measure, and may even become a dangerous one. The Plague Commission and others have shown that in the large majority of instances single cases only occur in each building. We must guard against the fallacy of being carried away by impressions, we must view the subject in the calm light of statistics. To take the latest available, it has been shown by Dr. Pearse, the Health Officer of Calcutta, that out of 1,826 cases in that city last year no less than 1,588 were single cases. In other words, 87 per cent. of infected houses had only a single case in them. Now, if evacuation of a house is adopted after a case has occurred in it, in the large majority of instances no further cases would have occurred, so that, generally, evacuation would be an unnecessary measure. It is obvious that this argument may also be advanced against disinfection. The danger of evacuation as a plague measure arises from the fact that it generates a panic and thus conduces to the spread of the disease. The fugitives are likely to carry infection to uninfected places. The truth of this statement can be demonstrated if we recall to our minds the rapid and extensive spread of the disease which followed the panic and flight associated with the first epidemic in Bombay.

Plague measures may with advantage be separated into two classes the essential and the non-essential.

In conclusion it is necessary to draw attention to the fact that the limited Indian Treasury is unable to withstand an unlimited drain on account of plague expenditure. Our budget for this purpose is strictly curtailed, so that the sum at our disposal must be carefully husbanded and expended to the best purpose. I have therefore divided the plague measures I have mentioned into two classes,—first, the essential and advantageous, and second, the non-essential and doubtfully efficacious. In the former group I include all those measures which aim at the permanent removal of the conditions which favour rat infestation, the destruction of rats where this cannot immediately be accomplished, the prevention of the importation of infection from infected to healthy localities, and, where all these measures have failed, inoculation. In the latter group I would register isolation and treatment of the sick in hospitals, disinfection and evacuation. The division of the measures I have considered into these two groups is further of advantage in that it enables me to show how different would be the expenditure on the various plague measures I support from that which at present is disbursed on them. I cannot do better than illustrate my point by a specific reference to the plague expenditure of Bombay city which annually allots two lakhs of rupees for this purpose. Of this sum there is spent 24,500 rupees on house inspection and the improvement of insanitary buildings, nineteen thousand on rat destruction, with five hundred on inoculation, while nothing is expended on the prevention of the importation of infection; making a total of approximately forty-four thousand, or less than one-quarter of the whole sum on what I consider to be essential measures. Fifty thousand rupees alone are expended on the treatment of the sick, twenty-nine thousand on disinfection and twenty-eight thousand on evacuation, a total of one hundred and seven thousand, or more than half of the available sum on non-essential and doubtfully advantageous measures.

Our new knowledge of the ætiology of plague demands a complete revision of our methods for combating the disease.

These facts show how radical are the measures I suggest, and I would go so far as to state that the researches of the last three years have so revolutionised our opinions as to how plague is spread that they demand that we should start with a clean slate.

I expect that the views I have propounded will be severely criticised, but I shall remain confident in their efficacy, knowing as I do that they are founded on the indisputable facts deduced from carefully conducted scientific experiments.

DISCUSSION.

Capt. Gordon Tucker said:—I was not present when Capt. Liston read his paper this morning, but I am informed that I shall be all right if I follow the paper the rough proof of which I have before me. I need hardly say that I always treat any statements made by Capt. Liston with the very greatest respect, and consquently I trust it will not be taken amiss if I

venture to advance the opinion that there are statements made in his paper which are extremely pernicious. In this discussion you must remember that plague workers in India are divided into two classes, first that to which Capt. Liston belongs, the bacteriologists, who have done work in Laboratories, on the excellence of which we are all agreed, but who have had no practical experience of the difficulties met with in plague work. The second class is that of the slum workers, who know more of the clinical than of the bacteriological side of the disease, and who have had experience of the great difficulties encountered in fighting the plague. It is from the point of view of the slum worker that I wish to discuss this paper.

When the ordinary I. M. S. Doctor is placed in a plague-infected town, the question he has to face is "What can I do to save these people in spite of themselves?" If he starts his work during the stage of local place infection he will have a few weeks in which to complete his preparations. He will recognise the complete accuracy of Capt. Liston's statement that importation of plague should be prevented, and that it could be prevented if certain measures which he indicates are carried out in a vigorous and persistent manner. In practice he will find that he cannot get these things done. It is also true that if there is wholesale rat-destruction the plague epidemic will be limited or prevented. But the plague worker's well laid scheme for rat-destruction is met with all sorts of obstruction passive or active. In one place the laying of traps is prevented; in another the baits are removed; in a third the rats are let loose after they have been trapped. I have tried poisoning the baits, and then the vermin are found dead, and it is hardly worth while to throw them away; by this means one can check a certain amount of rat-destruction. Even here sometimes people will throw away the dead rats, as they do not wish it to be thought that rats are dying in their houses.

Next it is quite true, as Capt. Liston says, that if the people submit to inoculation *en masse* there will be no plague epidemic, but what is our experience in practice? Take our experience in Surat some years ago, where in the matter of intelligence and education the population was above the average. We had lectures, public demonstrations, and pamphlets without number; men trained at Parel sent up to inoculate; and the local press helped us. The result was that about one hundred persons were inoculated out of a population of one hundred and seven thousand.

So that schemes for the prevention of importation, plans for rat-destruction, and inoculation fall to the ground and the plague worker recurs to the question "What can I do to save the people in spite of themselves." And it simply comes to this, that unless he has arranged for the plan of campaign which Capt. Liston discourages—evacuation—the plague epidemic will go on. It is true that evacuation means trouble and is expensive, but it is the only measure to which the plague worker need devote his supervision. With regard to the statement that in the large majority of instances single cases only occur in each building, my experience is that if people remain in their infected houses the consequence is always deplorable. We must take it that Dr Pearse's figures for a certain epidemic in Calcutta represent a statement of facts for that particular epidemic, but if they are taken as applicable to the usual plague epidemic in an Indian town, I say bluntly and emphatically that is not a statement of facts, it is not true. Major Lamb asked for figures. I have not had time to look up figures, but I can give facts derived from experience, and could produce figures from my old plague records. Times without number have I seen plague recurring in a family which had surreptitiously returned to its infected house, and plague continuing in a family which had refused to move out. In Poona City in 1898 the plan was followed of isolating plague contacts in their own homes, with deplorable results

We must also remember the possible fallacies in these figures of singly infected houses, due to the fact that the poor so frequently inhabit single rooms in a large building Each of the compartments inhabited by a single family is numbered, and from the postman's point of view the large building represents a collection of houses From the plague operator's point of view the collection of families represents one house only.

Nor is evacuation in plague seasons the impossible method which some people make out. I say this because I have done it. It is not suggested that in an intensely infected town of fifty thousand inhabitants evacuation material for that number should be provided, or anything like it. Evacuation of plague-infected towns has been unsuccessful because the system of standing camps, at a distance from the houses, has been followed. Into these the bulk of the people are unwilling to move. The only system which will do is that which I have called "The system of the Movable Health Camp" In this the temporary dwellings are run up opposite the peoples' doors and they can move out without trouble or delay; and they can form their own guards over their empty dwellings to prevent burglary. If it is objected that there is no room in a crowded Indian town to evacuate the population into the streets, I advise you when you are driving through the most crowded parts of Bombay to look round and see how much space you can detect on which temporary shelters can be run up. The method can be worked practically anywhere, and it is the only one by which in practice the plague operator can obtain success. I have no time to suggest what powers he should have. He should be given powers, to compulsorily evacuate infected slums: but only where he has been able to accumulate sufficient material in which to put the displaced population. This not only removes the people from their infected houses, but obviates the danger to which Capt. Liston has alluded,--of the displaced families carrying infection to non-infected towns. The idea of not providing hospitals is inhuman, for if the patients are left in their houses, they will practically all die.

Major Browning Smith said :—We are all, I think, greatly indebted to Captain Liston for the lucid exposition of his views on the prophylaxis of plague; they are based on our present knowledge of the ætiology of the disease which has been so admirably summarized by Major Lamb, based upon indisputably proved facts and, with such a basis, I do not see how they can call forth the severe criticism that their author anticipates; in so far as the theoretical value of the measures he advocates is concerned, I agree with him except perhaps on one or two minor points.

Captain Liston however qualifies his position as lacking the support of practical experience. In deciding upon the measures to be adopted for the suppression of plague and in gauging their relative value we must first of all consider, as Captain Liston has done, their theoretical advisability and, secondly, the possibility of their practical application, and so place them in their proper perspective before we utilize them for the purposes of our attack. I have been engaged for some six years in the Punjab in the campaign against plague and I should like now to claim your attention for a few moments while I discuss the practical side of the question as it appears to me from our provincial point of view.

Sanitation.—I think we must all be agreed that, if we could exterminate the rat or separate that animal from man, we should be free of epidemic bubonic plague; and the question of sanitary reform, as regards this disease, therefore, resolves itself into the problem of the diminution of rat and flea importation, that is to say, the provision of ratproof dwellings, the removal of conditions which provide shelter and food for the rat, scavenging, &c. While we must do all we can to improve sanitation and educate the people up to its advantages, we must, at the same time, recognize that little we can do can have any very appreciable effect on the present pandemic, for the re-housing of the people and so on must take generations upon generations to accomplish. Much, doubtless, can and ought to be done in the large and rich important towns and cities of India, but remember that these form but a very small part of the general problem.

Rat-destruction.—We have therefore to fall back on more temporary expedients for rat-removal and make what Captain Liston aptly calls a frontal attack on the arch enemy. I may perhaps incidentally remark here that, although he states that the

researches of the last three years have revolutionized our opinions, and that we now require to start with a clean slate, our frontal attack on the rat in the Punjab was begun four years ago.

The method first taken up was poisoning. It was gradually extended until in 1906-1907 operations were carried out on a very large scale. For details of the methods and the results obtained I must refer to my report on the subject which was published in the "Indian Medical Gazette," and will confine myself to the statement that, while in villages not baited the average plague mortality per cent of population was 5·5, in those baited once or twice during the plague season it was 3 per cent, and in those baited three times it was still further reduced to 1·14 per cent. These operations were calculated to have saved 40,000 lives in the 1906-1907 epidemic, which was the worst ever experienced and which caused the deaths of over 600,000 people. Although the saving effected may appear small in comparison with the loss, it was infinitely more than could have been brought about by any of the other means at our disposal; indeed I will go so far as to say that it was more than that produced by all the inoculation performed in the Punjab since plague first started.

On account of the temporary nature of the immunity afforded by one baiting, and the necessity, therefore, of at least four such operations during the plague season, it was impossible to continue these operations over large areas, and these were subsequently confined to particular cases which I will explain later, and we then looked for a more permanent method. Fortunately a guide to this was found in the work then being done at the two villages, Kasel and Dhand, by the Research Commission. Here it was found that, although no effort at diminishing the rat population was attempted, the rats had been reduced to half their original numbers by rat-trapping with a comparatively small number of traps; moreover, the mildness of the epidemic then was ascribed to this reduction. I commend this single fact to those who say that, owing to the fecundity of the rat, it is impossible to reduce their numbers. Systematic trapping was then taken up, first in municipal towns, and then extended to many endemic centres, the number of traps advised being two for every hundred of the population; this was considerably more than was used by the Research Commission, and advisedly so, because such supervision as was exercised at Kasel could not be contemplated generally. A special investigation was undertaken in 1907-08, and carried out by Captain Davys, I.M.S., to ascertain more definitely the reduction brought about by poisoning and by trapping with varying numbers of traps. Roughly, the results obtained were the following:—A single rat-baiting operation in a village killed from 60% to 95% of the rats, the average being 80%, that is to say, by a single afternoon's work, the rat population of a village could be reduced to one-fifth; rats were scarcely visible for six weeks and often longer after the baiting, their numbers then gradually increased, but even after some months had not returned to their original; with regard to trapping it was found that traps in the population of 1 per cent had no appreciable effect; with 2 per cent rats were reduced to about a half, with a temporary rise at the breeding seasons, but never to the original numbers, with 3 per cent. the reduction was more complete, the rise by breeding being less marked; with 4 per cent. reduction to a very low level was obtained and maintained, with larger numbers the reduction was no greater but was brought about more rapidly. Small villages require a less proportionate number than large ones and the proportion advised is 2 per cent for small, 3 per cent for medium, and 4 per cent for large villages and small towns; for protective measures larger numbers are not necessary. When infection has appeared in a locality which has not been systematically trapped 15 per cent. or one for every house, should be used in order to bring about a very rapid reduction. In large towns and cities rat reduction is a more difficult problem; in Amritsar city (population 200,000) 400,000 rats were killed in 1907, and 360,000 in the first nine months of 1908, which does not look as if any reduction had been effected; here I think we must rather depend on concentrated effort in and around localities as soon as infection appears than on general continued work over the whole city. Finally in rat-destruction we have the only measure which is readily accepted by the people; it interferes practically not at all with their comfort, gives them no trouble, appeals to their intelligence, has other advantages apart from plague prevention which they recognize, and is in fact the only measure that can be carried out in the absence of plague, a point of the greatest importance. In one of our districts all the villages are supplied with traps, most of which have been applied for and paid for at half price. I would therefore place rat-destruction first as the most practical and useful of all plague measures both for the prevention of epidemics and also for mitigating epidemics that have begun and preventing their extension.

Prevention of Importation.—If this could be universally carried out, epidemic plague would, I believe, be easily dealt with and controlled. We have learnt that the human case may be disregarded and the disinfection of clothes, &c., is alone necessary. Such disinfection can however only be practically applied for the protection of important places where it is possible to use compulsion; this is done, for instance, in the Punjab for the protection of Simla and Murree. Although we advise simple disinfection, such as exposure to the sun or immersion in boiling water, we cannot expect the people generally to adopt it until education is much further advanced than it is. At present the prevention of importation will be more easily attained by refusing entry into a healthy locality of the individual. Here and there this is actually carried out, but the obligations of the people towards guests, travellers, beggars, &c., are extreme and such action cannot be generally expected. While advising such measures and doing all we can to secure their adoption, I do not hope that much can be done in this direction.

Inoculation.—More than a million inoculations have been performed in the Punjab since the beginning of the epidemic. I have performed many thousands myself and the measure can have no keener advocate; nothing in all plague work is more satisfactory than the complete stopping of an epidemic by inoculating all the inhabitants; this however can rarely be accomplished. Moreover, the people will not accept it unless plague is present and danger imminent, even when they are accustomed to the operation and are convinced of its benefit, and it must be conceded that such a view is quite a rational one. Inoculation therefore, is a measure for saving as many lives as possible when an epidemic is in progress, and every effort should be made to secure its adoption; the immunity it confers is now undisputed fact, and requires no further reference from me. It is interesting to be able to calculate roughly the number of lives saved by this measure; from a very large number of operations done in infected localities in our inoculation campaign of 1902-03, it was estimated that two or three lives were saved for every hundred inoculated; it must be remembered that every person inoculated would not have contracted the disease if he had not been operated on.

Evacuation.—I am not quite in agreement here with Captain Liston and I would not dismiss this measure so summarily. Evacuation, as I understand it, does not mean the turning out of the inmates of a house in which a plague case has occurred but rather the evacuation of a number of houses which are in danger of infection. Total evacuation in towns is an impossibility, and in villages is extremely difficult, and will never be voluntarily adopted by the people to any considerable extent; although in a few places in the Punjab it is carried out on their own initiative directly infection is apparent there are particular reasons for this which I have no time to go into now. The objections to it are numerous and real and extremely difficult to overcome: the difficulties, for instance of providing shelter for man and beast, unfavourable climatic conditions danger of theft of property purdah prejudices, and so on. Something however can be done by partial evacuation. I have come across villages where the inhabitants on the appearance of plague in one part, remove themselves to another, and remain there until the disease appears among them in their new position, when they go back again to the part which was first infected, an excellent example

of intelligent deduction from observed facts. By partial evacuation I mean something of the same sort, we try to get the inmates of houses, in and around infected areas, to put up temporary erections in their courtyards and on the roofs of their houses and vacate the houses for a short time, a week or a fortnight, while rat mortality is going on in them ; this procedure is free from nearly all the objections that apply to total evacuation and so is much more readily accepted. It is practical and simple and can be carried out by the people themselves. We have heard from Captain Gordon Tucker of the movable health camp, and the partial evacuation I advise appears to me to be the same idea carried to its simplest form. With regard to the movable health camp, I would say that, in the Punjab it cannot be carried out as it involves compulsion, and, even if it did not, I do not see how the inhabitants of congested areas in towns could be evacuated into the narrow streets ; where such evacuation is possible, and compulsion can be employed, I quite agree that it should prove useful. Evacuation is a useful measure for saving life when an epidemic is in progress, and its practice on the most practical, simple and inexpensive lines should be encouraged.

Disinfection.—Little need be said under this head ; once infection has passed to the rat, no disinfection process will stop the disease spreading through a locality by the agency of that animal ; neither will it obviate the reinfection of a house. Disinfection of a house in which plague in man has occurred is, in my opinion, an entirely futile proceeding and any expenditure incurred on such operations is absolute waste of money. The only occasion, apart from the question of prevention of importation which has been already dealt with, when it may prove of some use, is immediately after rat mortality has occurred ; when so applied it may dispose of the infected fleas in the room, and so diminish, to some extent, the risk of infection of man.

Application of these measures in the Punjab.—This is to a great extent bound up with the question of recrudescence, and I venture to illustrate the position by a simile. When the conflagration of one season has died down to practical extinction, a few flames perhaps lingering in a small number of places, our attention is directed to these with a view to their final extinction; the still smouldering ashes, however, remain in a large number of places; although no actual fire is visible,we endeavour to locate these places and stamp out the danger ; where we fail and fire again appears, we try to prevent it spreading to the surrounding buildings and save as many lives as possible from the fire itself. Systematic trapping is carried on in most of the municipal towns,and in a very large number of potentially dangerous places, endemic centres, and places which are important diffusing centres ; the system has also been extended to cover certain definite areas. Baiting operations are performed in as many places as possible which became infected late in the preceding spring and where it is possible that plague may reappear ; these operations are purely protective in their nature, they cover an enormous area and their extent and success are limited by the staff available. When plague appears, a large number of traps are placed in the infected village (or concentrated in the case of large towns) to reduce the rat population as quickly as possible, and evacuation and inoculation carried out, the surrounding villages are visited and immediately baited to render them immune during the time the epidemic progresses in the infected one, and the inhabitants are appealed to to prevent the entry of any one from the infected village. These are the lines upon which we are acting, and if you will consider the magnitude of the area involved in infection, the thousands upon thousands of towns and villages, the general apathy of the people and their many objections to our operations, you will understand that the efforts made can only be partial and incomplete and attended with but a very limited degree of success ; we do what we can, where we can, with the means and staff at our disposal. Captain Liston has alluded to a point of the very greatest importance, namely, that the quiescent period and the time at the beginning of the epidemic before it passes completely beyond control is the time of all others when strenuous endeavour is necessary. In dealing with plague an appreciation of this fact is vital, an infinitely greater saving of life, although it can never be reduced to figures, is effected by delaying and aborting the beginnings of the epidemic than can ever be accomplished when the epidemic is in full swing.

The most important point of all.—By many of those who propound solutions of the plague problem from the chair of the office or the laboratory, the common mistake is made of presupposing an adequate medical staff and a perfect system of intelligence, and they altogether fail to appreciate the fundamental difficulty which confronts us. Such conditions can only be present in a few of the towns, even if there, and these are but a minute portion of the country ; the large majority of places can only depend on the rare and short visit of a plague officer. I therefore venture to formulate an axiom which must be the foundation of any plague policy if we are to hope for an eventual successful issue, and that is that *action must come from the people themselves*, and as they will not act on their own initiative they must be advised, educated, helped, stimulated and supervised by their natural leaders in the simple measures of plague prevention, which, requiring no technical skill, they can carry out for themselves. To this end their natural leaders must be educated and, in the Punjab, we are attempting to organize an auxiliary staff from this source Influential men are being selected and trained as local plague officers, one for every collection of villages, the zaildar being usually the most appropriate person, and these officers are asked to pass on their information and educate the village headmen and the inhabitants themselves. By these means it is hoped that skilled assistance will be at the door of every village. Good help is already being received from many such officers, especially in the early reporting of rat-mortality and in supervising rat-destruction ; they are supplied with pamphlets which deal with the subject in a simple manner, and such pamphlets are also distributed to schools throughout the country.

Gentlemen, I must conclude, but before I do so, I wish to make one more observation.

It is an unfortunate but natural circumstance that any temporary reduction in plague activity either at the end of a plague season or during a mild plague year is so readily seized upon as an excuse for relaxation of effort. It must be borne in mind that, as an historical fact, the city of London was infected for over a hundred years, during which time it suffered several severe epidemics, of which the last and worst is the only one now generally referred to. The fight against plague is full of disheartening circumstances, but progress, although very slow, is surely being made, and I believe that if we persevere, we shall, in the long run, win.

Dr. Master, in the course of his remarks, severely criticised the defective sanitary condition of Bombay, and the inadequacy of the present measures for the removal of town-sweepings. He condemned the sewage system as totally unsuited to the habits and customs of an Oriental population. Disinfection is done by unskilled coolies and not much could be expected from their efforts.

Dr. Cursetji supported the last speaker and advocated a better system of scavenging, which, he said, was the A B C of plague prophylaxis. Rat destruction, as carried out at present, was extremely inadequate, as the rat multiplies more rapidly than it could be destroyed. At least 20,000 rat-traps are needed for a city of the size of Bombay if Captain Liston's suggestions are given practical effect to. The present number of traps 2,5[illegible], and the rate of rat-destruction, about 400,000, were as a mere drop in the ocean. Wholesale evacuation for Bombay was entirely out of the question and Captain Gordon Tucker's suggestion about movable health camps in the streets was impracticable He quite agreed with Captain Liston that the amount of money spent upon disinfection was utterly wasted as the measure has proved entirely useless in checking the spread of plague. Inoculation has on the other hand shown good results, and requires to be well pushed.

Dr. Sukhia said that whilst Captain Liston blamed the people for supplying abundant food for rats, the real culprit was the municipality, as the dust-bin carts provided by that body furnished more than enough food for the rat-population. These carts are supposed to be cleared twice daily, but as a matter of fact they are generally emptied once a day, and often less frequently. Their number is extremely inadequate as shown by heaps of garbage lying around them. The condition and defective construction of the sewers, facilitating the constant intercommunication ot the rats between them and the houses, is another potent source for perpetuating the infection. Even gully traps and syphons are no bar to the rats, for they have been observed to jump through them and enter the down-take pipes. The present building regulations were defective. Rat-proof buildings should be constructed, and he could show what could be done by the outlay of Rs. 120 in rendering a house rat-proof. He had succeeded in making his own house rat-proof, and has thereby efficiently prevented the access of rats, so that not a single case of plague has occurred in his house whilst his neighbourhood was badly smitten, and numerous deaths had been recorded. He suggested the fixing of tinplates to the lower portions of doors, wire gauze to the barred windows, vertical bars to all openings of *nahnees*, and the raising of the lower end of down-take pipes about 2 feet above gully-level so as to ensure disconnection. The only flaw in such a rat-proof house was the water-pipe, which unfortunately could not be disconnected, as there would be no water-supply. Dr. Sukhia in conclusion suggested that the best method of dealing with the rat problem was to artificially create a disease in the rat, highly infective and fatal to it, but innocuous to other living creatures.

Major Lamb said that Capt. Gordon Tucker's statement that 7 to 8 corpses were found in one and the same house, at the same time, indicated that the infection in these cases had occurred almost simultaneously or at least within 2 to 3 days. Any measures of evacuation undertaken after such an event was like shutting the stable door after the horse has been stolen. He said that disinfection however thoroughly it may be carried out had proved entirely useless.

Mr. Ramchandrier said that rat destruction was the best prophylactic measure ; and that evacuation was practicable only in the case of villages. The rural population had not hitherto received its due share of attention in regard to plague, and it was time greater interest were taken in this regard. In Mysore the help of the priests was enlisted in recommending plague measures to the people and they depended mainly upon evacuation, and inoculation.

Major Clemesha was in favour of subjecting the kit and clothes of railway passengers to disinfection and the location of inspection stations *en route*. The difficulties in carrying out these measures were very great. In Madras they had a system of pass-ports, and surveillance of new arrivals. He thought that villages had been overlooked, the towns receiving too much attention and the villages too little, and suggested the laying out of model villages with model houses.

Dr. Nariman (Bhawnagar) made some remarks on plague prophylaxis and related his experiences in Katyawar.

Dr. Turner briefly replied to the criticisms upon the alleged shortcomings of the health department made by three members of the Corporation who had preceded him. He defended the action of that body and said that he had obtained all he wanted, and, although it must be admitted that at times it was slow, he had no cause to be dissatisfied as all his recommendations had been eventually adopted. He did not agree with Captain Liston with regard to the inutility of the hospitals, as not only many lives that would be otherwise lost were saved, but because patients received comforts, and even luxuries, that they could not possibly afford and much less obtain at their homes. He challenged anyone to disprove that pesterine was not the only and best culicide for the purposes of plague prophylaxis.

Captain Hutchinson said Captain Glen Liston in his interesting paper makes two important deductions :—

(*a*) That plague infection is carried from place to place by human agency ;

(*b*) That plague incidence in any area depends on the density of the rat population.

These facts must be brought home to the inhabitants of India to convince them of the necessity for prophylactic measures based upon them.

The comparative immunity of the people in North Kanara Collectorate is of course well known to the educated inhabitants of the plague stricken areas in the Southern Mahratta Country, while the true scientific explanation must go far in persuading the people to fight plague on the lines laid down by Captain Glen Liston.

The population of Kanara may be divided into three groups.

(*a*) Those living on the coast line. The towns and villages are not large, only two – Karwar and Kumta—having a population of over 10,000. There are of course some congested areas, but the feature of these coast line villages is that they are collections of small groups of houses, each house being detached, and on its own plot of land. Another point is that the cowshed is generally apart from the house. These are two points unfavourable for an excessive rat population. Rice and sugarcane are the chief crops, while the cocoanut palm is largely grown. The land does not support the inhabitants, who have to import grain for their own use.

(*b*) Those living in villages in the east of the Collectorate on the borders of Dharwar. These villages conform to the pattern described by Captain Glen Liston.

(*c*) Those living in the belt of forest separating the coast line from the eastern villages. Here the villages are scattered and comprise a few huts.

Plague in epidemic form has been limited to group (*b*). A few imported cases have been reported from the larger towns on the coast line, but there has never been an epidemic.

Communications are free by road, rail, and sea. Main roads connect Dharwar, Hubli and Belgaum with the coast ports of Kumta and Karwar.

The Southern Mahratta Railway runs into Goa, whence travellers can proceed by road or by sea to Kanara coast. Steamers call twice a week from Bombay, and Ratnagiri, and twice weekly from South Kanara ports. There is also a good deal of trade done by native craft.

In these several ways numbers of people are brought from plague infected areas, and no attempt is made to disinfect them or their clothing, or to prevent them from mixing with the inhabitants.

At certain seasons human traffic is heavy ; thus several large religious fairs are held in the District, notably the fair at Gokarn on the coast, and some of the inhabitants of the coast line visit the above ghat districts to obtain work in betel gardens

Thus people from plague infected areas are constantly entering this small immune area on the coast line, and plague cases have actually been brought in, but no epidemic has resulted. The inference is that the local rat-population is too small, but it has never been proved locally.

Similar conditions may have been investigated elsewhere, but nothing serves so well for an object lesson as something near home. If it can only be clearly demonstrated that the Coast population of North Kanara has been saved from plague by local conditions unfavourable to an excessive rat-population, the inhabitants of neighbouring plague stricken areas will undoubtedly wish to copy those conditions, and adopt for themselves suitable building regulations.

THE SERUM-THERAPY OF PLAGUE IN INDIA.

By Khan Bahadur N. H. CHOKSY, M.D. (Hon. Causâ), Freiburg,

Special Assistant Health Officer, Bombay Municipality, in charge of Arthur Road Infectious Diseases and Maratha Plague Hospitals, Bombay.

Like several other recent advances in practical medicine, the serum treatment of plague has had its due share of adverse criticism. We, who realised its usefulness as also its limitations, were however undeterred by such, inasmuch as the favourable impression it had created by the earlier observations became considerably strengthened by its more extended use, and impelled us to preach the gospel of serum-therapy. Realising fully as we did the virulence of the affection, its comparatively rapid course and the unfavourable conditions existing in India, we refrained from the very beginning from entertaining great expectations of brilliant results, nor did we acclaim it as a panacea under all conditions or circumstances. If in certain quarters the results fell far short of anticipations, and the treatment came into disfavour, the fault lay not with it, so much as with ignorant enthusiasm. Our want of knowledge of the pathology and bacteriology of the disease, together with the marked success of the antitoxin treatment of diphtheria, had much to answer for in this regard. The essential differences between an *intoxication disease* like diphtheria, wherein the toxin excreted by the microbes as a metabolic product is free and therefore capable of easy neutralisation, and plague, where the toxin is an *endo-toxin* contained within the bacterial cell, and requiring its disintegration before it can be set free and acted upon, were overlooked. Now, however, that many obscure points connected with its pathology and bacteriology have been cleared up, there remains hardly any excuse for not appraising the difficulties attendant upon the application of serum-therapy in plague, and laying down the limitations of its usefulness.

Certain general deductions drawn from the study of hospital cases during twelve epidemics of plague greatly assist us in the matter, and these are :—

(*a*) The case mortality rate at the Arthur Road and Maratha Hospitals in 13,023 plague cases was 74·5 per cent.

(*b*) In every 100 admissions, there are 58 septicæmic and 42 non-septicæmic cases.

(*c*) Of the 58 septicæmic cases, 55·6 die and 2·4 recover; of the 42 non-septicæmic cases, 18·9 die and 23·1 recover. The actual case mortality and recovery rates per cent. are therefore 95·8 per cent. and 4·2 per cent. in the septicæmic, and 45·0 per cent. and 55·0 per cent. in the non-septicæmic cases, respectively.

(*d*) Of the 74·5 deaths in every 100 admissions, 42 occur within 48 hours of admission :—26·5 in septicæmic and 15·5 in non-septicæmic cases ; on and after the third day, 32·5 more deaths take place, the septicæmic cases losing 29·1 and the non-septicæmic 3·4. Or to put in another way, 47·5 per cent. of all deaths in septicæmic cases occur within 48 hours of admission, and 52·5 per cent. thereafter, whereas the ratios are 82·0 per cent. and 18·0 per cent., respectively, in the non-septicæmic. The fact that the latter should succumb so quickly, and in such a larger proportion, is probably due to toxæmia, leading to rapid cardio-vascular paresis and heart failure before the development of septicæmia. Once however this fatal period has been crossed, the chances of recovery increase out of all proportion when compared to the septicæmic, that is 55·0 per cent. against 4·2 per cent.

The following statement shows the above figures in a tabular form :—

I.—*Table showing the Analysis of every* 100 *Admissions into Hospital.*

1	2	3	4	5	6	7	8	9	10
Cases.	Number.	Deaths.	Recoveries.	Case mortality rate per cent.	Recovery rate per cent.	Number of deaths within 48 hours of admission.	Number of deaths on and after 3rd day of admission.	Ratio of columns 7 to 3.	Ratio of columns 8 to 3.
Septicæmic ..	58	55·6	2·4	95·8	4·2	26·5	29·1	47·5	52·5
Non-Septicæmic	42	18·9	23·1	45·0	55·0	15·5	3·4	82·0	18·0

The great preponderance of septicæmic cases with the high mortality rate of 95·8 per cent. sufficiently explains the reason why the serum treatment, as judged by hospital results, has not favourably impressed those unfamiliar with the actual conditions of work at our plague hospitals. And if to these we add the rapid progress of the disease with an average duration of 5½ days in fatal cases and the comparatively late stage—between the third to the sixth day of illness—when the majority of hospital cases come under treatment, the futility of expecting remarkable successes from such material becomes self evident. These factors have been almost wholly ignored in criticising the hospital results. We have always maintained that the serum treatment, although it may and does prolong life in septicæmic cases, will not ensure recovery, and in my work on the Treatment of Plague with Prof. Lustig's Serum,* I have laid it down as one of the conclusions.

* The Treatment of Plague with Prof. Lustig's Serum by the Author, 1903, pp. 122-123.

Recent investigations by the Plague Research Commission however indicate that such is not invariably the case, and that recoveries are possible, although the percentage of recovery in them is as low as 4·2 per cent., and that too I believe is to a great extent due to the application of serum treatment.

THE RESULTS OF SERUM TREATMENT.

The results detailed below have been obtained from the application of Yersin's Serum from the Pasteur Institute of Paris from 1905—1908. The method adapted consisted in rejecting all those patients who appeared to have hardly any probability of benefitting by the serum treatment. Convalescent and semi-convalescent patients, as also all those in whom the period of illness had already lasted for six days or more, were also excluded. The latter for the reason that they are either too far advanced for treatment or are just beginning to improve spontaneously. The observations were thus restricted to the most acute cases within the first five days of illness. This procedure met with the approval of Prof. C. J. Martin, Director of the Lister Institute and Member of the Advisory Committee for Plague Investigation in India; and at his suggestion every alternate case left after rejecting as above was treated with serum, so as to obtain a group of serum-treated cases for comparison with another group of control cases in a series of 400. The combined results are thus tabulated :—

II.—*Table showing the Results of Treatment with Yersin's Serum*, 1905—1908.

580 Cases.

——	Number.	Died.	Recovered.	Case mortality rate per cent.
Serum-treated Cases ...	380	215	165	56·5
Control Cases	200	148	52	74·0
Serum-treated Cases ...	200	127	73	63·5
	Difference in favour of Serum-treated Cases.			10·5%
Total of Serum-treated Cases	580	342	238	58·9

The above figures indicate that the mortality rate in 580 serum-treated cases was 58·9%. If we compare the series of 200 control cases with an equal number of the former, we note a difference of 10·5% in favour of the serum-treated cases, and if the comparison is carried further between the controls and *all* the serum-treated cases, the difference comes to 15·1%. This, if translated into the actual gain in recoveries, indicated that whereas only 26 cases recover under the ordinary drug treatment among those acute cases that are not practically hopeless, the serum-treatment enhances the number to 41—equivalent to a gain of 57 per cent. in the recovery rate.

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How far the above results would have been bettered had all the septicæmic cases been excluded from the serum-treatment, it would be idle to speculate, inasmuch as bacteriological examination was not available. Considering, however, the fact that it is only in about 50% of the septicæmic cases that we can forecast the prognosis (as described in the previous paper), it can be safely assumed that about half the number of serum and control cases were septicæmic.

The rejected cases demonstrate by their final result that no benefit would have accrued to them had they been subjected to the serum-treatment :—

III.—*Table of Cases Rejected as Unfit for Serum-treatment or Controls.*

879 Cases.

Rejected Cases. *Duration of Illness.*	Number.	Died.	Recovered.	Case mortality rate per cent.
Between first and fifth day ...	572	556	16	97·2
Do. sixth and ninth day ...	185	111	74	60·0
Ten days and over	110	51	59	46·3
Pestis Ambulans	9	...	9	...
Too recently inoculated with Haffkine's prophylactic	3	1	2	33·3

The foregoing figures fully bear out the premises upon which the present method of serum-treatment was based. It indicates that 572 rejected cases between the first and fifth day of illness had practically no chance of benefitting by it, as shown by their high mortality rate of 97·2%. And it further supports the exclusion of the later cases, as their lower mortality rate by favouring the results of serum-treated cases would have obscured the real benefit derived from serum-treatment.

Such then is the result of our observations conducted at the public plague hospitals at Bombay. We see from the above analysis the serious difficulties attendant upon the use of serum-treatment on account of the inclusion of a large proportion of septicæmic cases and the factors that militate against its successful application. No one fully appreciating these would venture to assert, after a close study of the results, that the treatment was valueless in the fight against the disease. That it is not so valueless after all is demonstrated by its extensive use in Japan, China, Formosa, South Africa, Mauritius, South America, Australia, etc. The results from the latter country are indeed instructive when compared with our local experience. The treatment has been uniformly adopted at the Brisbane plague hospital since 1906, and intermittently so at Sydney and elsewhere in the Colony of New South Wales. I have been able to collect statistics of 282 cases, all whites, from the reports of Drs. Ashburton Thompson * and Burnett Ham † which indicate that the cases so

* Reports of the Board of Health on Plague in New South Wales, by J. Ashburton Thompson, M.D., Chief Medical Officer of Government, Sydney, 1900, *et seq.*

† Report on Plague in Queensland, 1900—1907, by B. Burnett Ham, M.D., Commissioner of Public Health, Brisbane, 1907.

treated had a mortality rate of 27·6 per cent. as compared with 38·3 per cent. among 603 untreated cases, a difference of 10·7 per cent. between the two classes,—almost exactly the same as that between the control and serum-treated cases at Bombay. This coincidence between two such widely separated countries and among different races is indeed remarkable, and points to the unmistakeable influence of serum-treatment in lowering the case mortality rate in plague in Australia as well as in India.

If we now turn to the consideration of the results in private practice, where the treatment is applied, under better conditions, at the homes of the patients and where, above all, early treatment by forestalling the septicæmia favours its application, there is no cause to be dissatisfied with them. Unfortunately, however, these conditions do not always obtain and exceptions are numerous. Often and often we are obliged to treat patients with almost hopeless prognosis in order to satisfy the feelings and sentiments of friends and relatives that everything possible was done to save life.* Such instances enhance the mortality rate, otherwise the difference in the results between hospital and private cases would be greater than what it actually seems. The treatment has been adopted at Bombay, Poona, Indore, Karachi, Calcutta, Patan, etc. With several workers scattered over different parts in India, it has not been possible to obtain full data, but I have collected a sufficient number for our purpose. The most important fact brought out by their study is that early treatment is the principal factor in lowering the mortality rate. That the incidence of early treatment varies very widely, and considerably affects the results is well illustrated by the following statement.

IV.—*Table showing the Proportion of First-day Cases to total Serum-treated Cases.*

—	Percentage of first-day hospital cases.	Percentage of first day private cases.	Case mortality rate per cent. of first-day hospital cases.	Case Mortality rate per cent. of first-day private cases.
Bombay	7	47	47·3	27·8
Poona	...	40	......	20·0
Indore	44	83	31·7	25·3
Karachi	..	85	......	25·0

The above figures, whilst exhibiting wide variations in the conditions existing at different places, indicate the large proportion of first-day cases treated in private practice as compared with hospital cases, and demonstrate the benefit thereby derived by the extremely low mortality rate varying from 20—27%. No better proof of the great efficacy of the serum-treatment when early applied than this can be adduced; in the words of Kitasato *the treatment should be applied at as early a stage of the disease as possible.*

* Fully 25 per cent. of the author's private cases belong to this category.

Drs. Pais, de Heredia and the present writer have treated 275 cases at Bombay out of the total 287. At Indore, Dr. Tambe was chiefly responsible for 119 cases, Drs. A. Contractor and Nazareth have contributed 112 from Karachi, and at Poona out of 60 cases Drs. Mody and Erasmus Dias have treated the largest number.* A few cases have been also treated at Calcutta and Patan. The following table exhibits the results in these cases:—

V.—*Table showing the Results of Serum-treatment in Private Practice.*

Places.	Number.	Died.	Recovered	Case mortality rate per cent.
Bombay	287	115	172	40·0
Indore	119	39	80	32·7
Karachi	112	28	84	25·0
Poona	60	25	35	41·6
Calcutta	23	13	10	56·5
Patan	3	1	2	33·3
Total ...	604	221	383	36·5

The above statement shows that the mortality rate varied between 25 to 41 per cent. depending mainly upon the proportion of first-day cases among the treated, Indore and Karachi therefore exhibiting the lowest mortality rate on account of their having the highest ratio. If we compare the above with the results obtained at the public plague hospitals, a striking difference becomes apparent.

VI.—*Table showing the Results of Serum-treatment in Hospital and Private Practice brought up to November* 1908.

—	Number.	Died.	Recovered.	Case mortality rate per cent.
Hospital Cases	755	424	331	56·1
Private „	604	221	383	36·5
Total ...	1,359	645	714	47·4

The difference of nearly 20 per cent. between the above sets of figures demonstrates the value of early treatment, which is the principal factor concerned in so greatly lowering the mortality rate among cases treated in private practice. And this becomes still further evident, if the mortality rate among *all* the cases is compared according to the duration of illness at time of treatment.

* For details, *vide* Serum Therapy of Plague in India, by the author. In addition to the above, 99 cases were treated at the Plague Hospitals at Indore, 67 cases at the General Plague, Military and Cantonment Hospitals at Poona, and 9 cases at the Parsee Fever Hospital at Bombay. All these have been included among hospital cases (*vide infra*).

VII.—*Table showing the Mortality Rates according to the Duration of Illness at the time of Treatment with Serum.*

Duration of Illness.	Number.	Died.	Recovered.	Case mortality rate per cent.
First Day	315	106	239	30·7
Second „	401	211	190	52·6
Third „	306	183	123	59·8
Fourth „	121	68	53	56·2
Fifth „	57	35	22	61·4
Sixth „	14	8	6	57·1
Seventh „	5	4	1	80·0

The lowest mortality rate—30·7 per cent.—is to be noticed in the cases treated on the first day of illness and thereafter it rises to 25·6 and 59·8 per cent. in those treated on the second and third days respectively, which means that it becomes actually twice as high if the treatment is delayed over 48 hours. The serum treatment to be of any value should therefore be applied before this period.

Analyse these results however as we may, they all point to one conclusion, *viz.*, the necessity of early treatment, which by forestalling the grave dangers of septicæmia, not only averts death, but actually robs the disease of its terrors, saves many a complication, and expedites recovery.

Before concluding the consideration of this part of our subject, a few facts dealing with the incidence of racial mortality in the serum-treated will not be without interest, as the treatment has been pretty freely applied among various communities :—

VIII.—*Table showing the Results of Serum-treatment among various Races.*

Races.	Number.	Died.	Recovered.	Case mortality rate per cent.
Europeans	16	5	11	31·2
Parsees	113	54	89	37·7
Mahomedans	199	86	113	43·2
Native Christians (mostly Goans).	245	112	133	45·7
Hindus	648	359	289	55·4
Japanese	1	...	1	...
Jews	5	2	3	40·0
Eurasians	5	3	2	60 0
Chinese	1	...	1	...

Europeans show the lowest mortality rate (31·2 per cent.). The number treated is, however, too limited for purposes of comparison. In Australia the whites had a mortality rate of 27·6 per cent. as compared with 38·3 per cent. among the untreated cases. Parsees follow closely with 37·7 per cent., then Mahomedans with 43·2 per cent., Native Christians with 45·7 per cent., and lastly the Hindus with 55·4 per cent. It is extremely curious to notice that in spite of the application of serum, there exist marked differences in their mortality rates among the various races, a feature that has been characteristic of plague at Bombay. The benefit derived from the serum-treatment varies from 15—25 per cent. if compared with the non-treated cases.

THE METHOD OF ADMINISTRATION OF SERUM AND ITS DOSAGE.

Two methods of administration, the intravenous and the subcutaneous, are open to us. The latter has been solely adopted in the above observations. The former, however, has been strongly recommended on experimental data derived from the use of the antitoxin treatment in diphtheria, and experiments with snake-venom. Henderson Smith* having conducted an inquiry into the subject thus summarises his conclusions:—

1. Antibodies in general are absorbed very slowly from the peritoneal cavity in lower animals, and from the subcutaneous tissues in man and animals. Absorption from the latter is not complete until at least 2—3 days have elapsed.

2. The amount of antibody present at any one time in the general circulation after intra-peritoneal or subcutaneous injection is very much less than the amount injected.

3. Clinically in urgent cases of the disease to inject antibodies subcutaneously is not only to lose 2—3 days time before the full action can be obtained but to reduce the amount of action that the dose injected can have.

4. By intravenous injection the maximum amount of action is obtained at once.

The above conclusions were deduced from experiments with the diphtheria antitoxin, where the presence of a free toxin allows of rapid interaction between it and the antibodies. In the case of plague, where the serum used is antibactericidal, and where bacteriolysis must be first brought about in order to liberate the endotoxin before it can be neutralised or eliminated, the process must of necessity be slow. If so, the system requires continuous and prolonged association with the antibodies. It has also to be remembered that rapidity of action means an equal rapidity in elimination, and consequently where a slower action is required as in plague, the system does not derive the full benefit from the application of the serum intravenously. And for this reason also, no appreciable reduction in the quantity of serum injected, as is anticipated, would be brought about by the adoption of the intravenous method, inasmuch as it would have to be supplemented by subcutaneous injection in order to keep up continuous action. Considering the distribution of the bacillus pestis and the comparative slower action of antibactericidal sera, I am inclined to hold that the intravenous method is not the one best calculated to bring about good results in plague. A combination of the intravenous with the subcutaneous method appears to me to hold out better prospects of success than either alone. It has been

* On the Absorption of Antibodies from the Subcutaneous Tissues and Peritoneal Cavity, by J. Henderson Smith.—The Journal of Hygiene, April 1907.

recommended by the Pasteur Institute of Paris, and its adoption at Brisbane has been attended with better results than by the subcutaneous method alone, the mortality rate having been reduced to 22·2 per cent. (in 45 cases) as compared with 27·1 per cent. (in 228 cases) by the subcutaneous method alone. The intravenous method was adopted in 9 cases only, with 6 deaths. The Plague Research Commission has taken up this branch of inquiry ; the observations made at the Maratha Hospital are as yet too few to allow of any conclusion. My conviction is that however successful the combination of the two methods may eventually be proved to be, its adoption in hospital practice would not be feasible on an extended scale during an epidemic, on account of the time involved in carrying out the intravenous method with due aseptic and other necessary precautions and the extra skilled assistance that would be necessary. In private practice it would be impracticable for the same reasons in addition to the reluctance of patients to submit even to subcutaneous injection. The subcutaneous method must therefore hold the field, as it hitherto has in the case of diphtheria. The method is easy of application, special skill is not required and any intelligent practitioner can carry it out after studying the directions laid down.* The best procedure is to inject 100 c.c. and to repeat the dose after 12 hours. Thereafter an interval of 24 hours is necessary when another injection of 100 or 50 c.c. may be given, regard being had to the general condition of the patient, his temperature and pulse, the size and tenderness of the bubo, etc. In all ordinary non-septicæmic cases, if treated within 48 hours, 250 to 300 c.c. thus administered will suffice. If the treatment is begun late, or if septicæmia is present, or the temperature persists and no amelioration in the patient's condition is noticeable after the third injection, further injections will be necessary, and should be repeated every 24 hours, the dose being gradually reduced as improvement progresses. In such cases, abrupt stoppage of the injections is not desirable lest relapse should occur. No hard and fast rules for repeating the injections after the third injection can be laid down ; every case must be judged on its own merits : but it is always safe to err on the right side and to use a little more serum than less.

After-Effects of the Serum Treatment.
" The Serum Disease."

These have been already fully described elsewhere† and consist of rashes (circinate, and scarlatiniform erythema) or urticara, local œdema, joint pains, pains in the muscles, and fascia and but rarely urticaria of the mucous membranes of the mouth, throat, eyes and urethra. Dr. Burnett Ham confirms my observation that the occurrence and severity of the above complications are independent of the amount of serum administered. But one point that has vividly struck me could not be noticed in Brisbane, *viz.*, that habitual meat eaters (Parsees, Christians and Mahomedans) suffer more than vegetarians (Hindus). Even among the former, the severity is never uniform, some escaping very lightly or without any appreciable after-effects, whilst others suffer very severely. The only preventive treatment as recommended by Netter consists in the administration of 15—20 grs. of Calcium Chloride or Lactate twice or thrice daily so long as the serum is being administered, and at least for a week after the last injection.

CONCLUSION.

Sufficient unequivocal testimony to the benefit derived from the serum treatment has accumulated by now to enable us to declare that it is our main line of defence in fighting the disease. Although the serum is by no means perfect, or capable of saving life under all circumstances and conditions, on account of the absence of antitoxic properties (that are so badly needed in septicæmic cases), and although its utility becomes thereby circumscribed, its usefulness cannot be gainsaid. It has been testified to by numerous workers all over the world. Not the least among them Prof. Kitasato of Tokyo says " that the good result to be obtained from the serum treatment admits of no dispute and that the most effective way to save the patients is to resort to both serum inoculation and extirpation of the buboes at as early a stage as possible." The latter procedure is however inapplicable to Indian conditions. Dr. Burnétt Ham says " that the immediate and remote results attending the administration of Yersin's serum, have been on the whole of a satisfactory nature. The opinions expressed by various Health Officers in charge of the patients at the Brisbane Plague Hospital from time to time are to the effect that with serum given early, and in sufficient dosage, nearly every case of bubonic plague not attended with complications should get well. Our observations covering a period of eight epidemic years convince us that the early introduction of large doses of serum was attended with the best results." And further " that there was no reason to believe that the sera in any way aggravated the disease, or that any unfavourable influence had been exerted when serum was therapeutically administered to patients actually suffering from plague or only presenting symptoms suggestive of plague." These opinions confirmed and strengthened as they have been by our experience in India, should leave no room for further doubt as to the efficacy of the serum treatment. And yet how often it is that we hear the expression that one has no faith in the serum treatment. I would venture to ask, what sort of faith is that? In the words of an eminent writer, " it is not merely unjustifiable faith, foundationless faith, faith without knowledge, but faith in opposition to knowledge, which in medicine is the worst form of scepticism, inasmuch as it is doubt of truth and belief in error, doubt which may prevent the saving of life and belief which embodied in practice, may kill." Unfortunately it does both in plague, when serum is purposely withheld. Of the grave responsibility thus incurred, I would leave you to judge.

* *Vide* Serum-Therapy of Plague in India, by the author, pp. 39-40.

† *Vide* Serum-Therapy of Plague in India by the author, pp. 39-42.

DISCUSSION.

Sir Bhalchandra in the course of his remarks congratulated Dr. Choksey on his excellent paper. He bore testimony to the good results obtained with the serum treatment in private practice and said that in all the cases where he had called Dr. Choksey in consultation for such treatment, success had been invariable. He was therefore a strong advocate of the treatment and had great pleasure in bearing testimony in support of the claims of the treatment. Sir Bhalchandra also referred to the benefit derived from prophylactic inoculation, and stated that although he had been inoculated seven times, he did not suffer from any ill effects. He thought that the cry against inoculation was unjustifiable and without foundation, and he appealed to the profession and the public to resort to it as the only preventive known against plague.

Mr. Kilkarni said that whilst appreciating the benefit derived from pathological and artificial sera, he would advocate the claims of the physiological serum normal salt solution which was being overlooked. He suggested that if both were used in combination or simultaneously the results would be better than by either alone, and appealed to the profession not to overlook this simple and efficacious remedy as an adjunct whenever a pathological serum was applied.

THE SYMPTOMATIC TREATMENT OF PLAGUE.

By KHAN BAHADUR N. H. CHOKSY, M.D. (Hon : Causá), FREIBURG,

Special Assistant Health Officer, Bombay Municipality, in charge Arthur Road Infectious Diseases & Maratha Plague Hospitals, Bombay.

Until serum-therapy comes into general use or a better antidote is discovered, the treatment of plague must remain symptomatic. Of the multiplicity of drugs and preparations vaunted as specifics, there is legion, but no drug that we know of at the present day, possesses any specific action against the infection. Under these circumstances, the symptomatic treatment of plague resolves itself in the words of Sir John W. Moore* (quoting from Dujardin—Beaumetz) into the "medication" of indications. How best to fulfil these is a matter of vital importance in such a rapidly fatal affection as plague. "For there is no other disease which so taxes to the utmost the resources of the physician. His attitude must day by day be one of *armed expectancy*," ever watchful, ever ready to forestall or control sudden and unforeseen developments. After an experience extending over 12 epidemics, we are in a better position to-day to lay down the broad outlines of symptomatic treatment than we were in the early days of plague. It is essential for the purpose to recognise certain well-established principles that considerably simplify our path by clearing away some prevalent misconceptions on the subject. These may be expressed thus :—

1. Plague is a self-limited disease with an average duration of 5½ days in fatal and about 10 days in uncomplicated bubonic cases.

2. There exists no known drug capable of aborting the disease, arresting or altering its course or preventing the development of septicæmia. The administration of internal antiseptics or germicides for the purpose is therefore utterly useless; their indiscriminate use singly or in combination is not unattended with harm to the patient. They do not reach the blood or the seat of infection in the same form and same strength in which they are exhibited; and if pushed too far, prove poisonous.

3. Pyrexia or fever being not a source of grave danger in plague, active inference with its course is to be deprecated. Adapting the words of Prof. Arnold Cantani of Naples in relation to enteric fever (quoted by Sir J. Moore) "pyrexia should be looked upon in the light of a general or essential, and—within certain limits—a beneficial reaction of the organism to changes in metabolism and in the blood due to the causative agent of the disease. This reaction is necessary to bring about cure, and pyrexia may be useful towards this end so long as tissue consumption does not give rise to exhaustion, and the heart muscle or the nervous system does not suffer from hyperpyrexia." Viewing the fever process in this light, "let us beware how we meddle with pyrexia *in plague*. The wholesale exhibition of the fashionable antipyretics of the present day—acetanilid, phenacetine, phenazone, as also of quinine—is fraught with serious risk. They open the flood-gates of heat-discharge (thermolysis), while they seriously interfere with heat production (thermogenesis) and so dangerous collapse is induced," all the more readily in the presence of the cardio-vascular paresis set up by the plague toxin. The exhibition of antiperiodics, antipyretics and even diaphoretics serves no useful purpose and should therefore be eschewed.

4. As plague kills at the heart, every effort should be directed to sustain and support the central and peripheral circulation. On the other hand, every measure tending to embarrass the circulation or lower the blood pressure, such as free purgation, active movement, &c., should be strictly avoided. Alcoholic stimulation has not been found on the whole to be beneficial to Indian patients as a cardiac remedy; apart from the large doses required to keep up sustained action and their injurious influence in aggravating hæmorrhages and exudations, alcohol inhibits phagocytosis and thereby seriously interferes with the elaboration of those defensive substances in the blood that are so necessary to antagonise the action of the plague virus in order to ensure recovery. If employed to control delirium, it signally fails in plague as it has been found to increase nervous excitement and thus to endanger the life of the patient. Whilst morphine or chloral hydras in small doses can be

* "The Practitioner," January 1904.

guardedly administered to patients for insomnia and delirium without risk, if alcohol is withheld, their simultaneous or concurrent exhibition is fatal.

5. Active interference with the bubo, such as incisions, is not to be recommended; all irritant applications and vigorous fomentations or poultices aggravate the local mischief by rapidly increasing the periglandular œdema.

If the above main principles are kept in view the symptomatic treatment of plague becomes greatly simplified. Fewer errors are likely to be made and many a pitfall avoided. The number of drugs required is consequently much reduced, and the much-too-tolerant stomach already irritated by the plague toxin, is only lightly taxed. But whatever the line of treatment it is subject to the limitations imposed by the presence of septicæmia and the extent of the cardio-vascular paresis when the patient comes under observation. The best of remedies fail in their presence; the worst possible line of treatment may succeed if they are absent.

The symptomatic treatment can be best considered seriatim according to the various systems involved :—

I.—Pyrexia or Fever.

Fever is best controlled by ice to the head, cold and tepid sponging or cold and tepid wetpack to the trunk only. If the temperature is high, rubbing of the shaved head with ice is very beneficial.

II.—The Circulatory System.

The most important indication in the treatment of plague being the support of the circulation, early measures to this end are needed, in spite of an apparently favourable pulse. Absolute rest in bed in the recumbent position is therefore essential, and must be insisted upon from the very beginning: it should be enforced for at least three weeks in every case; the duration must be prolonged until such time as the circulation becomes completely restored to its normal state and the wounds, if any, have come up to the surface. The longer the rest, the greater the benefit. The patient should not be allowed to sit up without outside help; the first effort is often risky, as the patient is liable to misjudge his strength, and by sudden exertion might bring on cardiac syncope even after perfect rest extending over 3—4 weeks. A back-rest should be provided at first and, as the patient gains strength and confidence in himself, he should be allowed to walk, at first with some help. If the above details are strictly enforced all risk of fatal syncope during convalescence is obviated. I am firmly convinced that many a life would be saved if the patient were to take to his bed immediately on the first signs of fever and pain in the bubo.

The cardio-vascular paresis requires not only careful watching but much discrimination in the choice of appropriate drugs and their mode of exhibition. Considering the fact that, even in cases of moderate gravity, their administration has to be prolonged for at least a fortnight, if not longer, no drugs possessing cumulative action or evanescent effects would be of much use, and hence this is an additional reason for withholding alcohol. After exhaustive trials with various remedies, singly and in combination, I have come to the conclusion that in the various preparations of the supra-renal gland we possess remedies that fulfil the above indications and that their intelligent use is unattended with any ill-effects. Voigt says that they exert a stimulating effect upon the action of the heart and raise the tone of the cardiac and vascular walls. Like other cardiac remedies their action has to be carefully watched, and, if they are found to irritate and thereby exhaust an over-taxed heart, the dose should be considerably reduced or their administration stopped. I have not come across any ill-effects from their judicious use in over 5,000 patients, nor had I occasion to note permanent after-effects upon the blood-vessels. These preparations are well tolerated even by infants; at an advanced period of life, when the arteries are hard or atheromatous, they should be exhibited with great caution and in smaller doses. Of the other drugs that supplement or enhance their action, there are but two only—strychnine and spartein sulphas—the latter an unknown remedy in plague, until I introduced it over 9 years ago. The action of the above remedies, however potent they may be, is limited by the condition of the neuro-muscular apparatus of the heart. If the paralysis of inhibition is profound and, simultaneously with it, the myocardium acutely degenerated, no measures are of any avail; success or failure with these agents depends therefore solely upon the above factors. The supra-renal preparations in general use are Sol : Adrenalin Chloride* and Ext : Renaglandin. The dose varies from 5—30 minims administered every 2 hours according to the state of the pulse. In hospital practice, the following has been found most suitable :—

℞.

Sol : Adrenal. Chloride ... vel Ext : Renaglandin	} M. 10-30 †	
Spartein. Sulph.	Gr. ½	
Liqr. Strychnine	M. 3	
Glycerine	M. 30	
Aquam	ad Oz. ½-1	

The above is to be administered every 2 hours, day and night, the patient receiving on the average 9—10 doses within the 24 hours. The quantity of the supra-renal preparations must be well regulated, and adapted to the state of the pulse. The maximum dose producing the best effect having been reached, it should be kept up for at least 3—4 days, and if the circulation is well sustained, can be gradually reduced, first in quantity and subsequently in frequency. It is never safe to reduce the dose too soon, however great the apparent improvement. In all cases of average severity, the above indications have to be carried out for at least a fortnight. When the patient either will not or cannot take the above

* *Vide* Cardiac Failure in Plague and its Treatment, and also Further Observations on the use of Adrenalin in Plague by the author. "Indian Medical Gazette," April 1905, and February 1907.

† Occasionally 20 minims may be required hourly; should no improvement be apparent thereafter, it is useless pushing the dose further.

by the mouth, it should be exhibited subcutaneously :—Adrenalin or Renaglandin M. 10—20 with Spartein Gr. $\frac{1}{2}$ and Liqr. Strychnine M. 3 at same or longer intervals as required. There exist, however, a few cases in whom the supra-renal preparations fail to give satisfactory results, being almost inert or producing extreme cardiac irritability even in small doses. Their use is contra-indicated under such conditions ; liquor atropine M. $\frac{1}{2}$-1 should be substituted instead in the above formula. If meningeal irritation is present as also in children and infants who are prone to it, strychnine should be withheld. A new preparation of digitalis, said to be non-cumulative and non-toxic, has been recently introduced under the name of *digalen* or *digitoxinum* soluble Clœtta ; Achert * has described its use chiefly in chronic cardiac affections ; should it prove to be all that has been claimed for it, it is deserving of trial in plague. Lastly, sudden cardiac syncope cannot be averted as it is almost always due to grave septicæmia. Any antecedent cardiac mischief or other cardiac complications of plague should be treated on general principles. Indian patients do not tolerate the applications of the ice-bag over the heart as recommended in extreme irritability.

III.—The Respiratory System.

The two most fatal complications requiring close attention are terminal pneumonia and subacute pulmonary œdema. Any increase of the respiratory ratio that does not correspond to the existing temperature or pulse rate requires careful watching ; if the number of respirations exceed 30 per minute it means that all is not well with the lungs though physical examination might fail to reveal anything. Terminal pneumonia is extremely insidious and almost always fatal, unless its area is much circumscribed. Often the first and only indication of its presence is shown by the characteristic sputum. Early and free counter-irritation to the chest (front and back) with liniment iodine and hot poultices, or antiphlogistine is required. If cough is troublesome stimulant expectorants should be administered with senega or squill ; should the sputum be copious and hæmorrhagic, calcium chloride is indicated (in 20 grain doses with glycerine 1 drachm and water 1 oz.) three or four times in the day with or after feeds or calcium lactate in powder similarly. Pulmonary œdema does not lend itself to any active treatment as it is the result of the vicious circle set up between the circulatory and the respiratory systems, each reacting upon the other and aggravating the mischief by inducing stasis and effusion, which in their turn further impede the circulation and overtax and exhaust the heart muscle. Œdema of the glottis might require surgical interference but it is usually of no avail in saving life. If moderate, the constant use of the bronchitis kettle with a few drops of oleum eucalyptus in the water, affords much relief.

IV.—The Alimentary System.

The mouth should be kept scrupulously clean, the lips, gums and teeth attended to with liberal applications of glycerinum boracis or lemon juice and glycerine. The bowels being usually confined, it is preferable to relieve them with simple enema to begin with, which might be repeated daily or every other day as needed. Irritability of the stomach such as retching or vomiting of nourishment or medicines yields readily to minims 10—30 of mist ; pepsine bismuth or cocaine hydrochloras gr. $\frac{1}{10}$-$\frac{1}{8}$ in a teaspoonful of iced water administered every half hour for 3—4 doses, and followed by iced soda and milk in very small quantities. Should it however persist, all nourishment by the mouth should be stopped and given by the rectum. Chloretone in 10 grain doses, is also efficacious in such cases ; profuse bilious vomiting is however troublesome and does not abate until all nourishment by the mouth is withheld for a few hours or longer; 5—10 grains each of bismuth subnitras and sodii bicarbonas placed upon the tongue and washed down with a small quantity of iced water every half hour until 4—6 doses have been given and repeated with the same frequency if it recurs. Only crushed ice should be given in the intervals. Hiccough is another very troublesome complication ; the above measures may be applied in combination with an ice bag or sinapism over the epigastrium or painting a broad band of iodine over the neck along the course of the pneumogastrics. Hot coffee or even a dry biscuit occasionally proves useful : but, failing all, hypodermic injection of ether or morphine grain $\frac{1}{8}$—$\frac{1}{6}$ or morphine grain $\frac{1}{8}$ and atropine grain $\frac{1}{150}$—$\frac{1}{100}$ may be needed. Occasionally all these measures prove inefficacious, and time alone is the only remedy.

The most serious abdominal complication is however tympanites primarily more paretic than due to intestinal putrefaction, with or without secondary mesenteric infection. In fact, the genesis of the cardio-vascular paresis, that of the paresis of the muscles of deglutition and intestinal paresis as well, is the same, *viz.*, toxæmia principally of the sympathetic system. Tympanites if severe becomes a serious factor in prognosis and requires early attention. If the condition of the patient would allow, 5 grains of calomel with an equal quantity of sodii bicarbonas with some carminative should be administered. Milk must at once be withdrawn from the dietary and thin arrowroot conjee substituted. Enemas of turpentine (ol : turpentine oz. $\frac{1}{2}$—1, white of one egg and thin starch gruel 1 pint) should be administered every 6, 8 or 12 hours. If these measures do not give adequate relief, salol grains 15, or turpentine (ol : terebinthinæ, spiritus etheris nitrosi, and spiritus chloroformi ā ā minims 10 with mucilage and water) should be administered and persisted with. A soft Jaques' œsophageal tube (size 16-18) well lubricated, should be inserted as high up the rectum as possible and retained *in situ* for 2—3 days ; it greatly facilitates the expulsion of flatus and thus relieves the patient. Turpentine stupes, or ice cold compresses to abdomen occasionally give relief. In a certain proportion of cases, all the above measures prove useless, the tympanites increases and further embarrasses the circulation by pressing upon the diaphragm. The Faradic current has proved useless in such cases ; eserine I have had no occasion to try and

* "The Lancet," 6th June 1908.

puncture of the intestine is but of doubtful value and not to be recommended.

Diarrhœa, if terminal, is but the beginning of the end and does not respond to any treatment. If early or from strong purgatives, it greatly lowers the pulse tension and becomes a source of danger and must be checked immediately. If due to default in the digestive powers, milk should be restricted or totally prohibited. Plasmon or Sanatogen are useful under such conditions, if administered in doses not exceeding 30 grains, well dissolved in thin arrowroot conjee at interval of 6 hours. Bismuth, dermatol, salol or hydrargium c. creta are all useful and occasionally 2-3 grains of Dover's powder enhance their action. Other complications of the abdominal viscera, such as mesenteric infection or localised peritonitis require rest to the bowel and external applications of belladona pigment and poultices. Opium should be avoided as it masks the symptoms and engenders a false sense of security.

V.—The Nervous System.

Of all the complications of the nervous system, the most important, and the one for whose prompt redress the surroundings of the patient clamour the most, is delirium. It varies from simple restlessness and insomnia, or incoherent talking, to low muttering or violent maniacal delirium with delusions and hallucinations; chiefly with pyrexia, but occasionally apyrexial also. Physical restraint by strapping the patient down to the bed is indicated in the presence of any kind of delirium and the more so when severe, as ordinary sedatives are practically useless in the latter. Two drugs only can be relied upon to control it, hyoscine hydrobromide and morphine. Considering its depressant action upon the circulation, morphine should be the last resort and should not be exhibited until the former has failed to subdue the delirium. Hyoscine hydrobromide should be used hypodermically in doses of gr. $\frac{1}{100}$—$\frac{1}{75}$; four hours at least must elapse before the injection is repeated, if found to be necessary. The pulse has to be carefully watched and cardiac restoratives continued regularly. It is not safe to give more than two such injections during the course of one night; in some cases a single injection remarkably succeeds and its repetition the following night is not required. Whilst in others, they appear to live and thrive upon hyoscine and even morphine. It is in such cases that the skill of the physician is greatly taxed, for whilst on the one hand he has to quiet the delirium which, if uncontrolled for any length of time, plays serious havoc with the already enfeebled circulation and brings on fatal collapse; on the other, he should be so precise in the choice of the remedies he selects for the purpose, that they should not unduly depress the heart. Extreme caution is therefore necessary in the use of hyoscine; unfortunately, however, there is no other recourse, as chloral, sulphonal, trional, veronal, paraldehyde and even chloretone prove ineffective. The rapidly labouring and exhausting heart with violent delirium indicates the use of oxygen by inhalation. The patient under the influence of hyoscine, or it may be morphine, should be kept constantly under oxygen until the circulation improves and he gets out of the enforced sleep refreshed and altogether another, a better and more tractable patient. And, as indicated above, if hyoscine fails after 2 to 3 injections, morphine in doses of gr. $\frac{1}{8}$—$\frac{1}{4}$ should be used hypodermically. In all other conditions short of the above, ammonium bromide in 10 grain doses with 1 drachm of tinct. hyoscyamus, or chloretone in doses of 10—20 grains has been found most useful. The latter is a good hypnotic and sedative, not depressant, nor cumulative. It does not, however, answer well with highly neurotic patients. It can be exhibited in all forms of delirium with safety, the first dose of 20 grains being followed up by one or two doses of 10 grains each at intervals of two hours if necessary. As delirium in plague has a tendency to recur day after day at about the same hour, it is always advisable to forestall it by administering the sedatives an hour or two before the time; this procedure saves much trouble and besides a second dose, if required and repeated about the time, soothes the patient more rapidly. In those cases, however, where hyoscine has been used the previous day, it is safer to begin with bromide and hyoscyamus or chloretone before resorting to it again.

Cerebral congestion occuring during the onset of the disease requires constant and vigorous rubbing of ice to the head; we scarcely come across a case with a full or bounding pulse who could stand direct withdrawal of blood. In passive congestion during the later stages, the accumulation of fluid in the ventricles and the arachnoid sac consequent upon stasis forbids any expectation of relief by such measures.

Actual meningitis with effusion of lymph is infrequent except in children; meningeal irritation is greatly benefited by the application of blisters over the temples, repeated if necessary, and the exhibition of bromides in combination with potassium iodide and sedatives. Convulsions, epileptic or other, should be dealt with as usual; atropine has been found very useful in association with the bromides. General nervous prostration in the acute stage requires a good restorative and the hypodermic injection of camphor (camphor 2, ether sulphuric 3, and ol. oliva 7 parts) in 20 minim doses, repeated every two or three hours, answers well. Besides the well known properties of camphor as a cardiac stimulant, it is antispasmodic and calmative, soothing the irritability of the nervous system and thus restoring tone to it. Nervous sequelæ, such as polyneuritis, glosso-labio pharyngeal paralysis, aphasia, &c., must be dealt with on general principles, regard being had to their toxic origin. Time is the great healer in such cases and nature without being unduly forced should be gently and judiciously assisted in throwing off the effects of the toxin. After all irritability has ceased, graduated injections of strychnine, the galvanic current and massage are requisite.

The most difficult complication to treat is marasmus. Acute marasmus is invariably fatal, due as it is to the sudden flooding of the system with the toxin liberated by bacteriolysis. The only possible means to

avert this catastrophe is an antitoxic serum—a desideratum for which we shall have to wait for some time yet. The late lamented MacFayden was about to take up this subject for investigation at my suggestion, but the ruthless hand of Death removed him from our midst. It is to be hoped that Sydney Rowland, one of his coadjutors and a member of the Plague Research Commission, will follow in his footsteps and apply to the extraction of the endo-toxin of plague the same processes that MacFayden had so successfully adopted in dealing with the typhoid and cholera endo-toxin.

Subacute marasmus with its long course, intense prostration, paresis or actual paralysis of locomotion and sensation and great wasting requires careful watching. Absolute and prolonged rest, appropriate and nourishing diet, the exhibition of strychnine and arsenic, the glycerophosphates, in solid form or as syrup, and above all, lecithin in tablets or fluid form must be judiciously applied, taking care to avoid over stimulation. These measures continued for a sufficient length of time may now and again crown one's efforts with success, otherwise the inevitable occurs. In some instances patients have to be kept in hospital for four to six months before they are able to get about.

VI.—The Genito-Urinary System.

Acute nephritis being almost always present, is not a grave complication if moderate, as the other symptomatic treatment sufficiently safeguards the functions of the kidneys. The milk diet and the administration of spartein sulphas not only tend to keep up the urinary secretion, but allow of the kidneys being soon restored to their normal condition. If grave, with considerable falling off in the secretion, the above measures supplemented with the use of diuretin and by dry cupping over the loins will be necessitated. Uræmia is an extremely rare but fatal complication of plague and must be treated on the same principles. Retention of urine is very frequent, and the catheter is required daily for some time. Burning in the urine is often complained of by patients taking the suprarenal preparations ; it is however readily overcome by temporarily reducing the dose and by alkalies in combination with hyoscyamus, etc.

VII.—The Special Senses.

The Eyes.—Keratitis and iritis require early attention ; scrupulous cleanliness, douching with warm boric lotion, boric compresses and the instillations of liq. atropine or eserine, as required, twice daily, alternately with dusting of calomel, usually answer well. It is advisable to keep the unaffected eye protected from light and glare. Panophthalmitis is so rapidly destructive that much treatment is not possible. The above measures however in addition to subconjunctival injection of sublimate (about gr. $\frac{1}{50}$—$\frac{1}{100}$) sometimes save one eye or the other. As there is generally a secondary infection, antistreptoccus serum or vaccine might be of some use.

The Ears.—Occasionally there exists inflammation of the middle ear ; it must be promptly attended to with the usual measures.

VIII.—The Osseous and Articular Systems.

Periostitis and periosteal abscess require appropriate treatment : surgical interference may be needed in the latter. Arthritis is uncommon, except among patients subjected to the serum treatment. The preventive treatment consists, as recommended by Netter, in the daily exhibition of calcium chloride or lactate in 15—20 grain doses, at least twice daily, so long as the injections are being continued and thereafter for about a week. Should it supervene in spite of the above, it is more annoying than dangerous, as it leads to much discomfort, pain and sleeplessness, especially if joint after joint becomes involved as is sometimes the case. Salicylate of soda or aspirin give relief : if these fail, large doses of potassii bicarbonate prove useful. Locally, methyl salicylate or betul-ol, should be gently rubbed in, and the parts covered with cotton wool. Opiates or other sedatives may be required if pain is very severe.

IX.—The Cutaneous System.

The specific manifestations of plague at the point of infection are at first phlyctenules and bullæ and subsequently cellulo-cutaneous necrosis. Excision of the phlyctenule should in no case be attempted : if hard and nodular or patent at the apex, it should be touched with pure carbolic acid. The bulla should be carefully cut open, the cuticle all round removed and the base cleaned and similarly cauterised, and carbolic compresses constantly kept on. If necrosis is present and a line of demarcation is visible, sublimate or carbolic compresses only are required. Should it be spreading with an angry areola, pure carbolic acid should be freely applied along the circumference and allowed to penetrate into the tissues. If effective, the amelioration becomes well marked within 24 hours; if not, further cauterisation will be required. Occasionally subcutaneous injections of sublimate all round the necrosis prevent its spread. Once the line of demarcation is formed, and the slough becomes slightly loosened, it should be removed and the depression left dressed with warm iodine (tinct. iodine one to two drachms to a pint) compresses. Healing takes place by granulation, and, occasionally, if a large surface is to be covered up, skin grafting is necessary. If granulations are exhuberant compresses of adrenalin solution (minims 40 to 1 oz. of water) ensure rapid cicatrisation. Acute ascending and descending lymphangitis from the seat of infection, and from the primary bubo, respectively, require cold compresses and elevation of the limbs ; if very painful, glycerine and belladona applications with poultices. Gangrene is a rare complication ; it can be arrested by subcutaneous injections of sublimate. General acne, herpes, &c., should be treated on general principles.

Erythematous rashes, the after-effects of serum treatment, can be prevented by the use of calcium salts. The curative measures consist in the application of ice, cold boric compresses or dry boric acid. Ointments containing menthol, one drachm to an ounce of white vaseline, or hazeline and vaseline, are required if pruritus is distressing. Pains in the muscles and fascia

are occasionally very acute, rendering every moment painful; these are best relieved by morphine hypodermically, or by the application of opium paste made with water well rubbed over the limbs and covered over with cotton wool and bandage.

X.—Hæmorrhages.

In spite of the exhibition of the supra-renal preparations, whose action appears to be somewhat variable where internal hæmorrhages are concerned, they are our sheet anchor in dealing with them; calcium chloride or lactate is required concurrently, but not in the same mixture. In hæmatemesis or coffee-ground vomiting, if the above is rejected by the stomach, the former should be exhibited subcutaneously. Ice is to be used liberally, as also an ice bag over the stomach and all nourishment by the mouth withheld. Hæmaturia, melæna and epistaxis could also be controlled by the same means. The latter yields readily to a douche containing 40 to 60 minims of adrenalin to the ounce. Hæmorrhage from the uterus requires ergotin. All other hæmorrhages should be dealt with upon the same principles. Thrombosis in veins requires rest, elevation of the limb, artificial warmth and other usual measures.

XI.—Local Treatment and Plague Surgery.

Three methods of treating buboes in the acute stage have been recommended: extirpation, incision and injection of germicides into them. Kitasato advocates extirpation of buboes at a very early stage of the disease, in combination with serum treatment. Unless it is performed as soon as the symptoms develop, it would be scarcely beneficial, considering the rapidity with which lymphatic infection spreads and involves other glands in the neighbourhood. The conditions under which we have to work in India and the great reluctance of patients to submit to surgical interference forbid anything like the acceptance of this procedure in routine practice. Wherever feasible, it should be adopted and serum simultaneously injected. Incision of buboes through the skin in the acute stage, dressing them and allowing them to exfoliate in time is not free from risk of setting up septicæmia, an objection fatal to its adoption. If at all, extirpation is to be preferred to it. I introduced the method of injection of germicides into buboes during the first epidemic of plague, using pure carbolic acid and also equal parts of the acid and liquor iodine; 10—20 minims were injected into each bubo by a hypodermic syringe, the injection being repeated once only after 24 hours. Like every other form of treatment, injections could not be made sufficiently early among hospital cases, and although the results were not altogether disappointing, they were not so good as expected. In a few cases there was rapid fall of temperature and general amelioration within a few hours with hardening of the bubo and freedom from pain. These were cases with single apparent bubo. I believe that this procedure of dealing with buboes in the early stage is capable of wider application either alone or in combination with serum treatment. It is easy, free from risk and has none of the disadvantages attached to the above two methods. Its field of usefulness is also to be found wherever serum treatment is not within reach.*

The relief of pain and tenderness in the bubo is a matter of primary importance in many cases; heat and belladona are generally enough for the purpose. If very acute, opium or aconitia ointment may be combined with belladona pigment. Poultices not too hot and changed every 2—3 hours should be applied, a layer of absorbent cotton intervening between it and the application. If periglandular œdema or infiltration exists, poultices or hot fomentations are to be deprecated as they have a tendency to increase the same; ice or cold compresses are to be preferred in those cases. Considering the gravity of buboes in the neck and the rapid increase of œdema, cold should be invariably applied to the neck. As soon however as any tendency to suppuration is noticed, poultices should be resorted to. Buboes should not be incised until fully suppurated, adequate time being allowed for the sloughs to become loose. No harm occurs by delaying the incision for a day or two if the temperature is not elevated. The buboes should always be laid open by a long oblique and free incision and the sloughs turned out. Irrigation and subsequent dressing with iodine lotion and gauze, lint or cotton saturated with it answers well in most cases; iodoform is hardly ever needed unless the cavity is foul. A bold incision at the outset, apart from facilitating the removal of necrosed tissue, enables a good view of the cavity, its thorough cleaning, the removal of deep sloughs or suppuration, besides saving all anoyance from troublesome sinuses later on. It is not infrequent to come across a layer of pus completely shut off by superimposed necrosed tissue, which itself forms the sac of the superficial abscess. The large blood vessels in the Scarpa's triangle, the popliteal space, the neck and the axilla, often lie in close apposition to the abscess cavity; much circumspection is therefore needed when removing deep-seated sloughs. After the cavity has been dressed regularly for a few days, it becomes clean; healthy granulations appear, and no further trouble is anticipated thereafter, as it fills up quickly and, reaching the surface, cicatrises rapidly. Such is the normal course, when the buboes involved are few, the sloughs loose, and no deep-seated suppuration exists. Otherwise the surgical interference required becomes extremley irksome alike to the patient and the physician. Iliac buboes, if suppurated generally, find an outlet into the lower incision; their treatment requires gentle handling, lest erosion of the underlying veins leads to rupture and hæmorrhage. If, on the other hand, they rise up well above Poupart's ligament, incision through the abdominal wall and drainage are requisite. Suppuration of the deep iliac, peevic and mesenteric glands, that of the spinal glands, the latter forming a psoas abscess extending from the lumbar vertebræ to Hunter's Canal, localised peritonitis, adhesions between the infected glands along the spine and intestines

* *Vide* Report on Bubonic Plague cases treated at the Arthur Road Hospital from September 24th, 1896, to February 28th, 1897—by the Author—1897.

leading to ulceration and hæmorrhage, or adhesions between the deep iliac buboes and the bladder, on the one hand, and the rectum on the other, causing urinary and fæcal fistulæ, are but some of the consequences of plague infection that tax the resources of the physician. The parotid and axillary buboes, if associated with deep suppuration, are no less troublesome to deal with. And again the whole chain of lymphatics and glands superficial and deep extending from the ankle to the thigh, or from the wrist to the axilla, may have to be removed by a series of incisions along the limbs.

Peri-glandular œdema, if serous, usually gets absorbed; occasionally it suppurates and we come across large bags of pus extending from the axilla to the crest of the ileum or from the cranium to the clavicle, &c. If fibrinous, it becomes organised and secondary streptococcus or staphylococcus invasions come into play, resulting in a large hard brawny mass that neither breaks down nor gets absorbed. The application of an appropriate vaccine is here indicated, as incision is practically useless and removal *en masse* a matter of doubtful efficacy, and difficult on account of the size and the involvement of the larger blood-vessels within it. If hœmorrhagic, coagulation takes place, and, if the buboes are incised, the clots can be removed; the after-treatment, though successful, is not free from anxiety. And lastly, unsightly cavernous cavities on the face left after the removal of necrosis have to be properly dealt with.

Erysipelas and tetanus, though widely dissimilar in their effects, owe their origin, more to the patient than to the primary affection. The former is often due to the patient scratching his wounds, especially when in sleep, and the latter to irritating and dirty applications, causing ulceration of the skin over the bubo. Anti-streptococcus serum has been found very useful in erysipelas; the nails of the patient should not be overlooked as a preventive measure.

XII.—Nourishment.

Milk, arrowroot, sago or cornflour, plasmon or sanatogen, should be the basis of all nourishment. Milk should be always given well diluted with conjees, barley water or soda water. Tea and coffee may be allowed in reasonable quantities: the exhibition of warm coffee is indicated between 3 and 5 a.m. when the vital powers are generally at a very low ebb. Meat preparations or soups are not indicated in the acute stage, the patient is better without them; all the more so when serum treatment is being applied. Plasmon or sanatogen in quantities not exceeding half a drachm can be given instead three or four times in the day; ice and iced drinks to be allowed liberally. After the acute stage has passed gradual increase in the dietary will be required and much will depend upon the habits, the usual dietary and the temperament of the patient. So long as the patient continues to take by the mouth the exhibition of nourishment is plain sailing. But in paresis of the muscles of deglutition or delirium when it is hard to get the patient even to open his lips, or when he squirts out everything given to him without any attempt at swallowing, different measures are indicated. Nasal feeding is useful in pares is if the patient remains quiet, but, should he struggle, all attempts should be abandoned as it often leads to cardiac syncope. The best procedure then is to feed by the rectum; nutrient enemas containing from 4-6 ounces of milk, peptonised or plain, one egg with a pinch of salt should be administered every 6 hours. If milk is not absorbed, or tympanites is present, starch gruel with plasmon or coffee with plasmon should be substituted. In grave tympanites, it is preferable to withhold all nourishment by the mouth or rectum for some time. The best method in dealing with obstinate or delirious patients is to add 30 grains of ammonium bromide and 2-3 drachms tincture hyoscyamus to each nutrient; the change after the administration of two to three such nutrients is extremely surprising; the patient who used to squirt out everything over the person of nurses or attendants, shows no further opposition and takes all with willingness. The rectum should be invariably emptied previous to administering nutrients.

XIII.—Nursing.

Intelligent, vigilant and careful nursing, so essential in a disease where the majority of patients succumb within a period of six days, needs no recommendation. Over-zealousness is just as dangerous as indifference, the rapid changes for the worse that occur so frequently require the presence of a responsible nurse, familiar with the disease in all its phases and able to do the needful before medical aid could be had.

The above then are the main indications in the symptomatic treatment of plague. To deal seriatim with each and every grade of the symptoms would be tantamount to writing an exhaustive treatise on medical treatment in general. Much that has been left out occurs in routine medical and surgical practice, and if new developments, unnoticed here, are met with, I am sure every intelligent physician will know how to deal with them.

DISCUSSION.

Sir Bhalchandra said that he would refer to but one point in Dr. Choksey's paper, *viz.*, the use of alcohol in the treatment of plague. He entirely agreed with his (Dr. Choksey's) views, and was of opinion that instead of doing any good in this disease, it did positive harm. The popular belief in the alleged efficacy of alcohol in warding off infection in plague had been but lately demonstrated, before a Special Committee, and he was glad to see that the concensus of pofessional opinion was against any such use for the purpose.

Mr. Kulkarni stated that Dr. Choksey's paper had a distinct merit inasmuch as it gave confidence to the profession that much could be done for the relief of suffering in plague by the judicious application of rational methods of treatment. This was a distinct step in advance as, during the earlier epidemics of plague, the professed inability of the profession to do anything led charlatans and quacks to allege that they could cure plague, when we, the doctors, failed. Confidence was the mainspring of success, otherwise the results would be disastrous to the credit of the profession. Dr. Kulkarni suggested the use of saline enemata, as also of normal salt solution by the mouth. He strongly animadverted on any policy that might lead the people to believe that there was no remedy for plague, and that they should resort to preventive measures alone. People had no

confidence in preventive measures; they would not listen to any recommendation for inoculation, but, if they were told that plague was curable, that doctors possessed special means and drugs to cure it, they would no longer hesitate to resort to hospitals for treatment, and many lives would be saved thereby.

Dr. Pant said it was a pleasure to listen to Dr. Choksey who was a great authority on plague and he himself had drawn many an inspiration from his writings. He agreed with Dr. Choksey as regards the baneful influence of alcohol in plague. He had found aspirin very efficacious in doses of three grains, thrice within twenty-four hours; he advocated the use of blisters over the bubo to relieve acute pain, the use of fruit juices, restriction of food, and avoidance of meat preparations. He thought it best to be guided by the inclinations of patients in these cases, than to adopt a mere routine line of treatment. Over-stuffing of the patient with food was just as pernicious as over-drugging, and in the long run what had proved useful was not the mandate laid down in the books, but the practical experience gained at the bed side.

Dr. Luchman Dass related his experiences with different lines of treatment, and supported the conclusions of Dr. Choksey with regard to the usefulness of the preparations of the suprarenal gland in the treatment of plague.

Dr. Benjamin agreed with Dr. Choksey's views about the use of alcohol, internal antiseptics, antipyretics and antiperiodics in the treatment of plague and condemned the routine use of acid carbolic and liq. hydrargyri perchlorid. He suggested the application of leeches over the buboes at an early stage of the disease.

ANTI-PLAGUE INOCULATION AT BANGALORE.

By Major R. F. STANDAGE, M.R.C.P. (LOND.), I.M.S.

I have ventured to address you on the subject of the prophylaxis of plague, because during the past 9 years I have been intimately connected with all that has been done to minimise the ravages of that disease in Bangalore, one of the largest native cities and military stations in Southern India. During that time I have seen many changes in the plan of campaign followed in fighting the disease, and have had exceptional opportunities of comparing the results of each. My remarks in this paper will deal with plague prophylaxis as attained by inoculation, and, more especially, with the very successful inoculation campaign which has recently been carried out in Bangalore, because I have formed a strong opinion, borne out, I venture to think, by the results among the inoculates in Bangalore, that in inoculation we have the one measure which, when it has gained the confidence of the people, can be applied to a large proportion of the community and which is strikingly successful in its results.

The inoculation campaign was started in Bangalore on 1st October 1907 and I would particularly draw your attention to the large number of inoculations carried out since that date, to the measures practised for getting so large a proportion of the community to consent to the operation and to the results as regards plague incidence among the inoculates, and in the whole population.

In Table 1 which accompanies this paper is given a comparative statement of plague attacks and deaths since the beginning of 1900. It will be observed that we have had a great many cases of plague to deal with, and that the epidemic follows the same course in Bangalore which has been observed elsewhere, being at its height during the colder months of the year.

During the hot months of the year 1907 Bangalore suffered but little from plague. In March, April, May, June and July, 59, 27, 33, 15 and 46 cases were recorded, respectively. In August, however, there was a marked increase, and it was determined to attempt to re-introduce anti-plague inoculation. Inoculation had been practised with some success in 1898, but since that year practically no inoculations were carried out in the station, all efforts made in this direction having proved unsuccessful owing to the unwillingness of the people to submit to the operation, being in many cases sceptical of its advantages and afraid of its results. To dispel the popular distrust, pamphlets, pointing out the protection conferred by inoculation and stating the hours at which, inoculation was performed at the plague offices, had been circulated in the Bazaar from time to time, but without any marked result as regards the bulk of the population. These pamphlets were again published and distributed in September 1907 and on the following 1st October the inoculation campaign started, but it was soon found that more energetic steps were required to overcome the apathy of the people and induce them to avail themselves of the protection offered. It was necessary actually to take it to the people and not to expect them to come to it.

On 7th October public inoculation was commenced in the New Market. The Resident and the principal Civil Officers were present and all the most prominent Hindu and Mahomedan gentlemen, some of whom were inoculated themselves. It was explained to the crowd by these native gentlemen that people of the cooly class who were inoculated would receive 4 annas compensation for any loss of wages which might result from being incapacitated for 24 or 48 hours. As a result of the enthusiasm engendered by these measures 1,536 people were inoculated during the first week at the New Market. During the first six weeks of the campaign the total number inoculated was 7,259, nearly all of the Pariah class, and it was noted that scarcely any Mahomedans had come forward. With a view to overcoming the prejudices of this community a meeting of their leaders was held in the Jumma Mosque on

18th November 1907 and the heads of the Mahomedan community were strongly urged to persuade their ignorant co-religionists to be inoculated. But little good resulted from this and the poor Mahomedans did not present themselves for inoculation.

Early in December 1907 it was found that the numbers coming for inoculation were falling off, and, as our object was to protect as large a percentage of the population as possible in the shortest time, it was determined at a meeting convened by the Honorable Mr. S. M. Fraser, the Resident, that since public inoculation, while proving a success for the labouring population, had failed to attract the higher classes and Mahomedans, an attempt should be made to reach them by providing facilities for inoculation in private houses. The scheme decided upon was that the leaders of the various sections of the community, both Hindu and Mahomedan, should invite their neighbours, women as well as men, to assemble at their houses, at a time pre-arranged to suit their convenience, in order to meet the Medical Officers and the Lady Doctor in charge of inoculation operations.

It is this "house to house" inoculation, started on 21st December 1907, which has been the special feature of the anti-plague inoculation campaign in Bangalore, and which has, I think, contributed in no small measure to our success. In Table II I give the figures resulting from this scheme and it will be seen that up to the present (15th December 1908), 14½ months after the commencement of the campaign, 40,573 inoculations have been effected, averaging nearly 3,000 a month or 100 a day. It may be of interest from the point of view of the practical application of inoculation to large sections of the community if I explain more fully the details of our scheme. In each principal street of the native bazaar, the house of a prominent citizen, with his consent and in most cases at his request, was converted into a temporary inoculation station. The prophylactic and all the paraphernalia for the sterilization of the needles and of the patients' skins were carried in a specially made hand-cart to the house selected for operations. Here the scene was a busy one; a pandal was erected under which the operations were conducted, a band was in attendance to attract crowds and doubtless to distract the patients' attention from their very slight sufferings. Doles of cakes, sweets and rice were given to the poor whose work might be stopped by the resulting fever, and all that could be done was done to make the measure popular. Householders indeed vied with one another to give the most attractive and successful "inoculation at home" and that they have succeeded in popularizing the measure among their friends may be gathered from the fact that as many as 714 were inoculated on a single morning, and that these 714 were of the hitherto intractable Mahomedan community.

As regards the operation itself the greatest care was bestowed upon the sterilization of needles and of the patients' skin. The operators, of whom as many as 4 worked at one time, stood at tables, on which were arranged syringes, needles and the "Kapadia" lamp for sterilization, provided with a special wind screen allowing the vaseline in the sterilizer to be kept at a constant temperature of 160° in the strongest breeze, a small stand for the bulbs of the prophylactic, a glass bowl containing carbolic solution 1 in 20 and a pair of dressing forceps, used for fixing the needles, after sterilization, on the nozzle of the syringe. A board, with the dosage of the prophylactic as recommended by the Parel Laboratory, was suspended near the table. A clerk stood near each operator and wrote the dose, bottle number, and brew on a small slip of paper, which was taken by the patient for registration.

The patient's skin was sterilized by Assistants, whose hands had been carefully sterilized under the supervision of the operators, and one by one, they were passed on to the operator who made the injection, and putting a small piece of cotton wool wrung out of carbolic lotion over the small wound, passed the patient on to the clerk's table where a dated certificate was given to him and his name, age, caste, address and occupation and thumb impression registered.

The ill effects from the operation (and the popular belief that they were many and very potent was hard to combat) have been practically nil. Beyond 3 or 4 cases of superficial abscess, which healed at once after treatment, no single instance of ill effect has been brought to our notice. There has been every facility to observe these effects because the bulk of the inoculates live in the heart of the town, belong to the working classes, and are easily accessible to enquiries made by the Plague officials.

I will now discuss the results of this campaign as regards the effects among the inoculated and on the course of the epidemic at large. Among the inoculated the immunity has been most striking. Table IV attached to this paper gives the number of attacks occurring among the inoculated since 1st October 1907, and it will be seen that they number only 33 and that the deaths among them were only 13. Table I will show you that the cases occurring among the whole population, which, including the Military, is 89,599 persons, were, during the same period, 1,673 with 1,391 deaths. The first attack of an inoculated person was on 19th October 1907, up to which date 3,239 inoculations had been performed. These figures are, I think, sufficiently remarkable but are even more striking if the plague attacks occurring among inoculates within 10 days of the operation are excluded, assuming that infection was previous to inoculation and not modified by it. Thus in Table IV Nos. 1, 4, 8, 10, 12, 19, 20, 22, 23, 25, 26, 27 and 31, should be eliminated, thirteen cases in all, with no less than 9 deaths among them. Excluding these from our list of attacks among inoculates we are left with only 20 attacks with 4 deaths, truly remarkable figures when the widespread epidemic in the bazaar at the end of 1907 and the beginning of 1908 is taken into consideration. As regards the results on the epidemic, I cannot

of course, speak so definitely at present. We have now nearly half the population inoculated and might expect a considerable falling off in the monthly number of cases, and indeed the figures are smaller than in previous years with the exception perhaps of 1901 and 1906. The decrease in the numbers has been especially marked in the later months of the year more particularly when compared with last year.

I recognize that as regards the number of attacks occurring among inoculates the figures quoted above are open to criticism. It will be pointed out that we cannot possibly trace every inoculated person among 40,573, that many may have gone away, and that in enquiring into the history of a case of plague we cannot always be sure that the fact of the patient's inoculation will be mentioned by the friends. I grant all this, but if you will allow me to give you a short account of our method for the detection of plague in the bazaars, you will, I think, agree with me that our chances of error are not very considerable. There are 3 District Medical Officers on plague duty, each of whom has been in his particular district for over 10 years. For the detection of sickness, deaths and arrivals by road and rail, the bazaar is divided into 28 blocks each in charge of a supervisor who, in most cases, lives in his block and is personally acquainted with all its inhabitants. The supervisor makes a daily round of his block, making notes of all cases for report to the District Medical Officer. Reports are also received at the plague offices from the friends of the sick, from private medical practitioners, and in the case of death from the cemetery overseers. On receipt of information a District Medical Officer visits every reported case of suspicious sickness in his district daily, and in case of death a detailed enquiry is made into the patient's antecedents and last illness before a death certificate is granted. In the course of such enquiries it is unlikely that the patient's recent inoculation would be forgotten by the friends—indeed they are only too likely to blame the inoculation for the sickness, and the inoculation certificate would be produced as evidence in support of the accusation. A considerable proportion of our inoculations, too, were on the Military and Regimental followers whose subsequent history can easily be traced. I think, then, that we may very fairly claim that our figures are reliable.

As I have no new or original work to report, my paper may be inordinately long, but, if I have, by a record of my practical experience, been able to further emphasize the value of widespread inoculation for the prevention of plague, and to interest you in our methods for applying it to nearly half our population in little over a year, and in the saving of life effected thereby, I feel that the time has not been wasted. The value of plague inoculation is no new story ; Col. Bannerman and Capt. Liston have told us of it, and Major Wilkinson's figures for inoculations in the Punjab are conclusive ; in fact all who have had experience of it are in favour of it. The problems in connection with it are (1) how to get a large proportion of the population to consent to it, (2) does any disease or harm result to the individual from inoculation, and (3) how long does the protection last. As regards the first of these our method of taking inoculation to the people has met with fair success ; for the second I can answer emphatically in the negative, for we have had no report of harm resulting from the operation. The third problem, I hope, we shall hear something about during the sittings of this Congress.

TABLE I.

Comparative Statement of Plague Attacks and Deaths from 1900 *to* 1908.

Number.	Months.	1900.		1901.		1902.		1903.		1904.		1905.		1906.		1907.		1908.	
		Plague attacks.	Plague deaths.	Plague attacks.	Plague deaths.	Plague attacks.	Plague deaths.	Plague attacks.	Plague deaths.	Plague attacks.	Plague deaths.	Plague attacks.	Plague deaths.	Plague attacks.	Plague deaths.	Plague attacks.	Plague deaths.	Plague attacks.	Plague deaths.
1	January ...	71	67	521	390	644	473	296	260	667	493	289	232	222	186	112	97	196	164
2	February ...	58	45	266	219	425	297	107	95	411	318	240	196	181	126	91	75	136	110
3	March ...	65	56	139	116	270	202	66	64	210	162	130	105	145	115	59	46	62	57
4	April ...	29	25	44	34	95	77	16	16	54	44	67	60	54	48	27	25	18	19
5	May ...	7	6	18	15	37	30	18	13	32	29	60	57	44	40	33	28	26	24
6	June ...	10	8	16	14	67	57	15	10	66	58	77	70	37	36	15	15	18	18
7	July ...	11	6	20	13	104	85	19	20	93	77	82	75	49	49	46	37	16	16
8	August ...	35	33	12	11	228	166	67	55	197	154	101	90	107	100	107	87	39	32
9	September ..	40	34	24	21	483	378	115	85	360	257	205	158	89	77	214	178	146	113
10	October ...	354	258	47	34	1,181	897	361	265	427	395	365	279	121	110	319	241	112	86
11	November...	900	745	184	140	1,112	857	662	529	567	368	330	264	112	90	252	212	79	67
12	December ...	918	734	382	279	748	561	786	625	279	219	342	268	101	100	232	214	22*	18*
	Total ...	2,498	2,017	1,673	1,286	5,394	4,080	2,528	2,037	3,363	2,574	2,388	1,854	1,262	1,077	1,507	1,255	870	724

* For 15 days.

TABLE II.

Number of Inoculations performed between 1st October 1907 and 15th December 1908.

	Europeans and Eurasians.		Hindus.		Mahomedans		Native Christians.		Total.		Total of all Classes.
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	
Civil ..	541	308	14,746	9 988	2,792	421	3,973	2,998	22,052	13,715	35,767
Military ..	..	..	.	..	..	..	..	..	..	..	4,806
Total ..	541	308	14,746	9,988	2,792	421	3,973	2,998	22,052	13,715	40,573

TABLE III.

—	Population.	Plague attacks.	Plague deaths.	Case incidence per cent.	Case mortality per cent.
Inoculated ...	40,573	33	13	·08	39·3
Uninoculated ...	49,026	1,640	1,391	3·4	83·1

TABLE IV.

Plague Attacks and Deaths among Inoculates since 1st October 1907.

Number.	Plague attacks.	Plague deaths.	Recovery.	Date of inoculation.	Date of attack.	Date of recovery.	Date of death.	Remarks.
1	1	..	1	9-10-07	19-10-07	27-11-07	....	
2	1	..	1	9-10-07	1-11-07	8-11-07	....	
3	1	..	1	26-10-07	17-11-07	3-3-08	....	
4	1	1	..	2-12-07	8-12-07	....	8-12-07	
5	1	..	1	21-10-07	11-12-07	4-1-08	....	
6	1	1	..	9-10-07	24-12-07	....	24-12-07	
7	1	..	1	29-10-07	28-12-07	4-2-08	....	
8	1	1	..	19-1-08	24-1-08	....	24-1-08	
9	1	..	1	Not known (inoculated by Military).	27-1-08	29-2-08	....	
10	1	1	..	20-1-08	29-1-08	....	29-1-08	
11	1	..	1	26-10-07	9-2-08	28-2-08	....	
12	1	1	..	4-2-08	12-2-08	....	13-2-08	
13	1	1	..	23-9-07	21-2-08	....	29-2-08	
14	1	..	1	31-1-08	22 2-08	12-3-08	....	
15	1	..	1	22-1-08	2-3-08	17-3-08	....	
16	1	1	..	Jan. 08	9-3-08	....	14-3-08	
17	1	..	1	26-1-08	13-3-08	3-5-08	....	
18	1	..	1	28-1-08	20-9-08	15-11-08	....	
19	1	1	..	26-9-08	28-9-08	....	29-9-08	
20	1	1	..	28-9-08	30-9-08	....	30-9-08	
21	1	..	1	Sept. 08	1-10-08	31 10-08	....	
22	1	1	...	29-9-08	8-10-08	....	9-10-08	
23	1	..	1	2-10-08	8-10-08	26-11-08	....	
24	1	..	1	Sept. 08	9-10-08	9-11-08	....	
25	1	1	..	8-10-08	9-10-08	....	13-10-08	
26	1	..	1	5-10-08	11-10-08	31-10-08	....	
27	1	..	1	21-10-08	26-10-08	18-11-08	....	
28	1	1	..	27-12-07	4-11-08	....	20-11-08	
29	1	..	..	23-10-07	10-11-08	....	....	Under treatment in Plague Camp.
30	1	..	1	1906.	24-11-08	14-12-08	....	
31	1	1	..	25-11-08	29-11-08	....	29-11-08	
32	1	..	..	10-4-08	29-11-08	....	....	Under treatment at Home.
33	1	..	..	8-10-08	4-12-08	....	....	Under treatment in Plague Camp.

DISCUSSION.

Dr. Deva said:—Captain Liston has very ably discussed the prophylaxis of plague and there is so much in the paper that is new, instructive and suggestive. He has divided the plague measures, now being adopted, into the essential and non-essential classes and includes evacuation in the non-essential class. No doubt to carry out evacuation is an expensive measure and when not properly supervised is not a sure remedy. My experience has been confined to Sangli and the neighbouring villages which have suffered heavily from the ravages of plague during the last ten years. Partial evacuation, not very strictly supervised, has been resorted to by the people of their own accord, and the measure has been found from experience to be fairly efficacious. Some people leave the neighbourhood altogether, but many others camp outside the villages in temporary huts erected for the purpose and thus ensure to themselves a fair amount of protection. There seems to be no doubt that the rat-flea is the principle agent of communicating plague from rat to man and of spreading the disease. Are not the chances of contracting plague diminished by avoiding a place where the rats are infected and going to a temporary shade where the surroundings are such as do not allow shelter to rats? Experience shows that evacuation confers partial protection and consideration of the causation of plague leads one to expect the same result. As the measure of evacuation has been stated to be non-essential by such a high authority as Captain Liston it is but necessary that others should state their experience so that an idea which is not supported by experience may not gain currency and thus lead to serious consequences in a few instances at least. I add my own humble support to everything else said in the paper.

Dr. Standage has suggested three problems in connection with anti-plague inoculation, namely—(1) how to get a large proportion of population to consent to it, (2) does any disease or harm result to the individual from inoculation, and (3) how long does the protection last? During the last four years I have done about 15,000 inoculations in Sangli and in the neighbouring villages. In my opinion there ought to be no doubt about the efficacy of the measure in the mind of any medical man who has resorted to it to any extent. I would not take up your time by making any observations as to how to make the measure popular. If one can induce the leaders of a village to submit themselves for the operation, others follow without much trouble. In some villages such a confidence has now been created that people of their own accord go several miles to a permanent inoculation centre for being inoculated. I instituted inquiries to find out if any evil results had resulted from the measure, two years after I did my first 8,000 inoculations. I can positively assert that there was found not a single individual who had suffered any material inconvenience from inoculation. Dr. Standage's 2nd problem I answer in the negative. I now make a few observations regarding duration of immunity conferred by anti-plague inoculation. In six villages with a population of 9,585 I had inoculated 1,584 people in the year 1905 in the months of August and September. These were affected by plague in the last quarter of 1907, *i.e.*, exactly two years after the inoculations were done. I depend for my figures not only upon official statistics but upon inquiries made on the spot, after the epidemic had ceased, regarding each individual inoculated. All these villages not having a population of more than 2,000 souls, every individual could be easily traced out. I can guarantee absolute correctness of the figures given below:—

———	Population.	Attacks.	Deaths.	P. C. of deaths to Population.
Uninoculated ...	8,001	487	350	4·3
Inoculated ...	1,584	36	20	1·2

Below for the sake of comparison I append another table showing the protective value of inoculation for a period of one year:—

———	Population.	Attacks.	Deaths.	P. C. of deaths to Population.
Uninoculated ...	21,994	1,378	881	·4
Inoculated	2,996	33	10	·33

Whereas the proportion of death-rate from plague amongst uninoculated and inoculated was 12 to 1 within a period of one year after inoculation, it was found to be 3·5 to 1 two years after. The figures show that the immunity enjoyed gets less and less as time advances; but certainly lasts though diminished for over two years.

However rigorous anti-plague measures may be, one cannot expect that in the near future we can create a sanitary India. Camping out in the case of those that can afford it, and inoculation in the case of the poor, appear to be the only remedies that can be relied upon for some time to come. Will the influential people from amongst the public come forward to assist the medical men in carrying out these?

Dr. Sukhia said that besides Haffkine's method of immunization against plague, there were four other methods of which nothing had been said. He referred to the methods suggested by the German Commission, Prof. Shiga's method and some others, and hoped that they should receive due attention at the hands of observers.

Mr. Ramchandriar said that he had used only Haffkine's method, and applied it among 4,700 people, only 13 out of them had been attacked, and 6 of them succumbed. The results must be considered very encouraging. Inoculation conferred comparative immunity, but it was impossible to guarantee absolute immunity. He said that inducements in the shape of money—eight annas per every individual inoculated—should be given in villages. He did not think that the period of immunity conferred by inoculation lasted 6 months only, and agreed with Capt. Davys' views that it might extend to 2 years.

Capt. Liston said that he was greatly struck with the figures presented by Major Standage. He thought that they were too good to be true, and that there must exist some error somewhere.

THE RECRUDESCENCE OF PLAGUE.

By Major S. BROWNING-SMITH, I.M.S.

1. *Preliminary Note.*

I have chosen this subject because it appears to me to be one not only of great interest to those engaged in the plague problem from the research point of view but of the greatest importance at any rate in the north of India, to those employed in dealing practically with the epidemic which has been devastating the country for so many years. My experience, now extending over more than six years, has been confined to the Punjab, and the observations made in this paper are based upon this experience and are not intended to apply to other parts of India; variations in climate and other conditions lead to epidemiological differences, and what may be true for one part of the country may not be so for another. It will be well perhaps in the first place to explain the particular meaning which I attach to the term chosen as a title for this paper.

2. *Definition.*

By the recrudescence of plague I mean the reappearance of the disease, not due to importation, in a locality which has been previously attacked, after an interval more or less prolonged, during which there have been no apparent signs of infection in man or rat, apparent, that is, to the unaided eye.

3. *The Present Investigation.*

It has long been recognized in the Punjab that the annual seasonal epidemic depends, not so much upon the extension of infection from those few places where signs of plague activity linger throughout the summer, though these are naturally of importance, as upon the reappearance of the disease in localities which have been apparently free for some time. In 1907, as far as time and staff would allow, a special effort was made to investigate carefully the first reappearances of infection in a certain number of selected districts with the object of tracing the source of infection, and a series of consecutive cases have been collected in each district, in some instances amounting to every locality infected during the epidemic season, 1907-08. The year 1907 was particularly favourable for such an enquiry, because the epidemic was slow in its onset and did not extend rapidly, and also because local epidemics were often slight in extent and consequently the spread by importation was less rapid and extensive than usual.

4. *Value of the Evidence.*

Before examining the figures it is necessary to say a few words regarding the nature of the evidence obtained and its value. The investigations have been carried out by medical officers experienced in plague and in its methods of extension; as soon as possible after infection appeared, the infected localities were visited and the evidence of the local officials and people was taken. Although there is, in some instances, an attempt at concealment of the facts, this is not usual now-a-days in places accustomed to the presence of plague; the reporting of deaths at any rate is extremely good, and it is more often that disease is wrongly reported as plague than to find concealment of its presence; moreover, in the latter case the epidemic is certain to come to light as soon as it becomes at all extensive, and it is practically certain that, in the various district series of cases recorded, no infection has been missed and the series are complete as far as they go. It is usually comparatively easy to obtain a fairly accurate account of the observed facts from the local inhabitants, such things as plague cases and rat mortality, from past experience, being regarded by the people as very important facts in village history; they are recognized and remembered and cannot well escape observation, and when a clear history is obtained of the plague epidemic and epizootic of the past season and of rat mortality pre-

ceding or during the one under observation, it would appear very unreasonable to doubt the statement that no rat mortality had been observed in the interval. Without, therefore, claiming infallibility or impossibility of error, it is legitimate to maintain that the facts obtained are substantially correct.

5. *Analysis of the Figures.*

The total number of localities investigated with the object of discovering the source of infection was 277, obtained from 12 districts; in four of these districts, Jullundur, Hissar, Gujrat and Mianwali, all infections occurring during the whole plague season are included. In the remainder a certain number only, consecutive from the first infection of the season. These cases may be divided into five classes showing:—

(*a*) Evidence that signs of active infection persisted throughout the period of abatement, and connected one season's epidemic with the next.

(*b*) Evidence that infection was imported in clothes or property, the human agent having contracted infection previous to arrival.

(*c*) Evidence that infection was definitely imported in clothes or property, the agent escaping, or only suffering subsequently to the infection of the rat population; in these cases the evidence being definite in that the commencement of the epizootic coincided in place with the entry of articles from an infected locality.

(*d*) Evidence that, although no definite connection could be proved between the origin of the rat epizootic and importation from an infected locality, yet communication with an infected locality was possible or probable, and importation may have occurred. In this connection it may be noted that many cases are included in this class in which importation was improbable, and a great number are possibly recrudescence. It is evident that, with an increasing number of infected centres, communication of some sort or another becomes increasingly common, and such cases accordingly become more numerous as the seasonal epidemic approaches its maximum, until, in a bad year, such communication may be shown in nearly every case. This means that evidence of absolute exclusion of importation becomes more and more rare; recrudescence in the later periods of the epidemic, therefore, may be, and probably is, masked to a great extent; this does not, however, prove that recrudescence becomes more rare.

(*e*) Evidence of recrudescence, inasmuch as no evidence could be obtained of any possible source of importation or of connection with the previous season by signs of active infection; in these cases infection, although not apparent, must have been present in the village for a longer or shorter period of time preceding the signs of renewed activity.

The following table shows the numbers of these different classes in each of the districts investigated during 1907-08:

—	Complete.				Ferozpore.	Ludhiana.	Hoshiarpur.	Ambala.	Gujranwala.	Amritsar.	Gurdaspur.	Lahore.	Total.	Percentage.
	Jullunder.	Hissar.	Gujrat.	Mianwali.										
Total number investigated	18	42	2	1	21	19	22	20	39	22	32	8	277	..
a. No interval	..	1	..	..	..	1	5	2	..	..	1	1	11	4·0
b. Importation (human cases.)	4	16	..	..	7	3	6	4	5	3	3	2	52	18·8
c Importation (clothes &c. definite.)	1	12	..	..	1	1	..	..	2	..	1	93	18	6·5
d. Importation (possible indefinite.)	4	5	..	..	7	7	6	6	7	9	11	..	70	25·2
e. Recrudescence.	9	9	2	1	6	7	5	8	25	10	16	28	126	45·5

Perhaps it may be noted here that in about half the cases recorded in the above table, where importation was effected through the agency of a person actually suffering from or incubating plague at the time (class *b*), such importation did not result in an epidemic; in these cases the infection was limited to the imported case and they might have been excluded from the series.

With reference to the present investigation, the only classes that have to be considered are (*a*) where there was no interval of freedom, and (*b*) recrudescence.

The first of these will now be examined.

6. *Signs of active Infection Persisting during the Summer, connecting two Epidemics.*

Out of 277 cases, there were eleven instances of this or 4 per cent. These include all cases where signs of active infection appeared in the interval; in eight were such signs more or less continuous and in three there were none for considerable periods of time, and the latter form a link between this and the recrudescence class. Three of the most definite instances occurred in the hilly part of the Hoshiarpur district, and this is what might naturally be expected, for here the climatic conditions, upon which the hot weather subsidence depends, are not so strongly marked as in the plains. With regard to the others, they occurred in widely separate parts of the country, and no explanation can be offered why signs of active infection should persist in them, when in other places, similarly situated, they had disappeared. As these are very important, the complete series of cases for 1907 are given below as briefly as possible.

CASE 1. Village Delon, Una tahsil, Hoshiarpur district, population, 2,884. Plague was imported on 16th March, 1907, followed by rat mortality, and 27 deaths occurred between this date and 17th

June; rat mortality went on continuously though not to a great extent throughout the summer, and the first case of the next epidemic occurred on 27th August. The first reported infection of the season in this district.

CASE 2. Village Raipur, Una tahsil, Hoshiarpur district, population 983. Plague imported from Delon on March 29th, 1907; ten deaths between this date and 20th July; rat mortality continued up to the first case of the next season's epidemic, which occurred on 30th August. The second infection in this district.

CASE 3. Village Bhannam, Una tahsil, Hoshiarpur district, population 859. An epidemic in the early summer probably due to importation, first case 20th April, 1907, and the last on 31st July. Rat mortality continued after the last case and up to the date when the first of the next season occurred, on September 13th. The fourth infection in this district.

CASE 4. Village Banokheri, Ambala tahsil, Ambala district. An epidemic of 25 cases beginning in May and ending on July 6th, 1907. Rat mortality continued. A suspicious case on July 22nd, and the first case of next epidemic on August 18th. The first reported infection of the 1907-08 season in this district.

CASE 5. Village Bhagowale, Batala tahsil, Gurdaspur district, population 2,879. Plague imported on 4th November, 1906, resulting in an epidemic of 96 cases, the last being on June 22nd, 1907. Rat mortality continued, and five human cases between 26th July and 4th August—no further case until the last week of September, when five more cases are recorded; rats continued to die upto the middle of November, but no further cases. This village is well known in the district as the one where the annual epidemic first makes its appearance.

CASE 6. Village Jabbo Mazra, Samrala tahsil, Ludhiana district, population 604. Fifty-nine cases between 25th October 1906 and 30th May, 1907; rat mortality continued intermittently up to the occurrence of the first case of the next epidemic on 30th October. An interval of five months between the two epidemics, bridged by rat mortality. In the particular house of the first person infected in the second epidemic, dead rats had been noticed for some four months, one or two a fortnight for three months, and more numerous during the month before the case occurred.

CASE 7. Village Manawala, Kasur tahsil, Lahore district. Plague was practically never absent from this village from September, 1906 to August, 1907, during which period 47 deaths occurred, seven in 1906 and forty in 1907. No plague reported in September, 1907, but the first case of another epidemic occurred on October 10th. No rat mortality was noticed in connection with this reappearance.

CASE 8. Village Kharbala, Hansi tahsil, Hissar district, population 1,326. Plague imported by clothes on 1st May, 1907; rat mortality began on 5th May followed by first case on 20th May; 16 cases occurred between the latter date and 30th June; another case on 5th July, and another on 12th August, and another on 22nd September; rat mortality continuing all through this period; three cases occurred in the last week of September and thirty-seven from 1st to 18th October when the epidemic came to an end. This is a very marked instance of the continuance of active infection both in man and rat. The next three cases are really examples of recrudescence inasmuch as there were intervals of freedom; they have however been inlcuded in this series as active signs of infection appeared in the so-called free season; they form an interesting link between those given above and those given later as examples of recrudescence.

CASE 9. Village Dhab, Hoshiarpur tahsil, Hoshiarpur district, population 686. Forty-five deaths between 29th November, 1906, and 3rd February, 1907. No further signs of infection till the end of August when two rats were found dead. A girl died on 13th September with a history of fever and an inguinal bubo which was probably plague. No further signs until the end of October when rat mortality was noticed followed by first case on 27th October. There is a long interval here and the case would legitimately be classed as recrudescence following a complete epidemic.

CASE 10. Village Buddha Bar, Dasuya tahsil, Hoshiarpur district. Twenty deaths between 14th December, 1906, and 7th April, 1907. No further signs until the beginning of September when a few rats are said to have died. The next appearance of active infection was a case on 3rd November, 1907, preceded by a few days with rat mortality. Practically a recrudescence following a complete epidemic.

CASE 11. Village Dharmgarh, Kharar tahsil, Ambala district, population 200. Thirty-seven cases between 2nd February and 17th March, 1907. A woman died of plague on May 13th, this death being preceded by rat mortality for ten days and also followed for the same length of time. No further signs, until rat mortality was again noticed on October 20th, the first case on November 11th, leading to only four cases in all. Practically a recrudescence in May and another in October, following a complete epidemic.

7. *To what Extent do these Infections lead to the next season's Epidemic?*

The question that now arises is to what extent these infected localities, which showed signs of active infection more or less continuously during the period of abatement, led to subsequent infections by importation into other places. There were eleven such places in the twelve districts investigated, out of a total of 277 cases examined. In only four out of the remaining 266, was infection traced to connection with these eleven. It may

therefore be concluded that these places contribute to only a small extent to the seasonal epidemic, and that the principal origins for this must be sought elsewhere. The reason for this appears to be that where, for some reason or another, plague attacks the rat population with sufficient severity to render mortality apparent throughout the summer, it is probable that but few rats remain and no extensive epizootic can take place when the plague active season arrives and consequently the resulting epidemics in these cases are as a rule very limited in extent.

8. *Reappearance of active Infection not arising from fresh Importation after a period of apparent freedom, i.e., Recrudescence.*

In 126 cases out of 277 investigated, or 45·5 per cent., signs of active infection reappeared without any evidence, either definite or indefinite, of importation being obtained, while in 140 or 50 per cent. importation was proved in seventy,—and possible in seventy others. That is to say nearly half the total number of epidemics at least were due to a recrudescence of plague, following a period where no evidence could be obtained of any signs of active infection in man or rat. It is these cases more especially that constitute the subject of this paper. These will now be considered in detail and can be divided for the purpose into several interesting classes, recrudescence occurring (*a*) after complete epidemics the previous season, that is to say, where the epidemic has run its course completely through the locality, (*b*) after incomplete epidemics, where the epidemic has been cut short by the hot weather before completing its course, (*c*) after importation in the spring where no epidemic has followed at the time.

Other points that will be examined are the duration of the period of apparent freedom, the definite connection in place of the spring infection and subsequent recrudescence and cases of multiple recrudescence occurring in different parts of the same locality at the same time. Also some interesting cases where plague has reattacked, as a first case in an epidemic, an individual who suffered during the previous one, and also where recrudescence has begun as a case of pneumonic plague. The fact of recrudescence being established it will be also interesting finally to consider whether any general laws can be deduced from the observed facts.

9. *Recrudescence following Complete Epidemics.*

By a complete epidemic is meant one which has practically run its course through a locality coming to an end apart from the influence of the hot weather. This is followed by an interval more or less prolonged after which plague manifests itself again without any evidence of importation. A few cases are given as examples.

Case 12. Village Khudda, Dasuya tahsil, Hoshiarpur district. A noted endemic centre annually attacked by plague. Plague recrudesced here on September 29th, 1906, and 122 cases occurred between this date and 25th April, 1907. No rat mortality or human cases were noticed until 18th October, 1907, when the first case occurred, preceded for a few days by rat mortality. No evidence of importation; no infected villages near. Interval 5½ months.

Case 13. Village Ranjitpur, Rupar tahsil, Ambala district. Twenty-two cases occurred between 12th December, 1906 and 6th April, 1907. Perfect freedom till 4th December, 1907, when the first case of next epidemic occurred preceded by rat mortality for one to two weeks. No evidence of importation; no infected villages near. Interval 7 months.

Case 14. Village Muddal, Amritsar tahsil, Amritsar district. Fifty-eight cases between 26th January, 1907, and 6th April, 1907. No sign of acute plague till 10th February, 1908, when the first case occurred, preceded by rat mortality for two weeks. No evidence of importation; in a quite uninfected area. Interval 10 months.

Case 15. Village Barila, Gujrat tahsil, Gujrat district. 244 cases between 11th February, 1907 and 14th May, 1907; no plague till another case occurred on 23rd February, 1908, preceded by rat mortality for eleven days. No evidence of importation; the only infected village in the district. Interval nine months.

Case 16. Village Pinda Rori, Batala tahsil, Gurdaspur district. Thirty-two cases between 29th January, 1907 and 4th May, 1907, following importation. No further rat mortality or human plague till the first case of next epidemic which occurred on 15th March, 1908, preceded by rat mortality for a week. No evidence of importation; no infected villages near. Interval nine and half months.

Case 17. Village Chamiari, Jullundur tahsil, Jullundur district. Thirteen cases between 22nd February, 1907 and 28th March, 1907. No further plague till a sporadic case occurred on 16th April, 1908; no apparent rat mortality, no history of importation, no infected villages near. Rat destruction had been carried out here in late autumn. Interval 12½ months.

Case 18. Village Upal Khaira, Phillaur tahsil, Jullundur district. Ninety-five cases between 13th March, 1907 and 25th May, 1907, no further signs till March when rat mortality was noticed; this continued until 1st case occurred on 12th May, 1908. Interval about nine months.

10. *Recrudescence following Incomplete Epidemics.*

By an incomplete epidemic is meant one which has been brought to an end by the advent of the hot weather before it has completely run through the locality.

Recrudescence in those cases tends to occur earlier than in those where there has been a complete epidemic, and the interval is shorter. Rat mortality often continues *after* the epidemic is ended; in complete ones the epizootic comes to an end before the epidemic. A few cases are given as examples.

CASE 19. Village Makhanwindi, Amritsar tahsil, Amritsar district. Twenty cases occurred between 27th March and 28th June, 1907; slight rat mortality was noticed after the last case. The first case of the next epidemic occurred on 23rd October, 1907, preceded for two weeks by rat mortality; no evidence of importation; no connection with any infected village. Interval, $3\frac{1}{2}$ months.

CASE 20. Village Dawlonangal, Amritsar tahsil, Amritsar district. Five cases between 11th May and 1st June, 1907. First case of next epidemic October 21st, 1907, preceded by rat mortality for ten days; no history of importation; the only infected village in the district at this time. Interval $4\frac{1}{2}$ months.

CASE 21. Village Thandi Serai, Jullundur tahsil, Jullundur district. Four cases between 9th May and 24th May, 1907; the next case occurred on 4th January, 1908; no evidence of importation; the only infected village in the district at this time. No rat mortality was observed. Interval $7\frac{1}{2}$ months.

CASE 22. Village Kilchpur, Kharian tahsil, Gujrat district. Thirty-eight cases between 17th May and 12th June, 1907. Next case on 16th April, 1908, preceded by rat mortality for ten days, no evidence of importation; only one other village infected in the district, which was also due to recrudescence. Interval 10 months.

CASE 23. Village Sojan, Dasuya tahsil, Hoshiarpur district, 8 cases between 9th May and 18th June, 1907; the next case occurred on 16th November, no rat mortality was observed but a bad smell was noticed in the houses where recrudescence appeared. No evidence of importation and there were no infected villages near. Interval 5 months. Interesting in that it shows that although rat mortality was not apparent it probably was occurring.

CASE 24. Village Nakki Brahmanan, Shakargarh tahsil, Gurdaspur district. Four cases following importation occurred between 4th May and 1st June, 1907; the next case on 17th January, 1908, preceded by rat mortality for a fortnight. No evidence of importation; no connection with infected villages. Interval 7 months.

11. *Recrudescence following Importation the previous Spring without any Epidemic.*

These are perhaps the most interesting cases of the whole series for often a very definite connection in locality between the importation and the recrudescence can be shown. A considerable number of such cases come to light and constitute one of the strongest arguments not only for the fact of recrudescence, but also that it occurs after considerable intervals of apparent freedom. These important cases must be given in more detail.

CASE 25. Village Ratiya, Fattehabad tahsil, Hissar district, population 3,383. A case of plague was imported into this village from an infected village in Patiala territory on 23rd April, 1907, rat mortality began a few days after the arrival of infection; only one other case occurred, on 1st June, rat mortality continuing for a few days after. The next case occurred on 9th August preceded by rat mortality for 15 days. The interval, when there was no apparent rat mortality or cases, was quite a short one, about one and a half months. There was no evidence of importation to account for the rat mortality or the case of August 9th, but the latter occurred in a house quite close, though not attached by common walls to the house where the case occurred on 1st June. This epidemic lasted till December 4th, with a total of 66 cases and 44 deaths. After another free interval of nearly 3 months another case, preceded by rat mortality for 10 days, appeared on 10th March, a small epidemic of 5 cases resulting between this date and 21st March. No evidence of importation to account for this second epidemic. It is interesting to note this double recrudescence in one plague season, each occurring at the time when plague is most active, the autumn and the spring.

CASE 26. Village Daryapur, Fattehabad tahsil, Hissar district. A small village of 357 inhabitants. A person, suffering from plague, came from an infected village in Patiala State on the 1st April, 1907, and died. No rat mortality was noticed in connection with this case at the time. but about the 6th September slight rat mortality was noticed in a house adjoining the one in which the original case stayed, and on 23rd September a plague case occurred in this house; there was no history of importation to account for the rat mortality or the case. The epidemic resulted in 16 cases, ending on 15th October. The interval between the importation and appearance of infection was more than five months.

CASE 27. Village Tohana, Fattehabad tahsil, Hissar district, population 5,931. Between 22nd February and 20th May, 1907, 17 cases were imported into this village which appears to have been looked upon as a safe haven by adjacent infected villages in Patiala State. All these cases were removed outside the village in less than 24 hours after their arrival except one, Chumnia, a mahajan; in his house a dead rat was observed in May and he immediately evacuated; slight rat mortality was noticed in connection with this but no indigenous cases occurred. About the 3rd October rat mortality began in a house, close to that of Chumnia, and in 3 or 4 others which had common walls with the first; the first case occurred in this house on 13th October. There was no evidence of importation to account for the infection. The epidemic

was a very small one ending in the second week of November with a total of only five cases. The interval was at least four months. This village was again infected in the spring by importation, some guests came from an infected village, Chagli, in Patiaila State, on 20th February, 1908; rats began to die a few days later in the house in which they stayed and on the 5th March, a case of bubonic plague appeared; this epidemic was also a small one of only ten cases in all, the last occurring on 7th April.

Case 28. Village Juggian Kokaran, Sharakpur tahsil, Lahore district. This is a very small village of only 40 inhabitants, living in 5 new houses. A case of plague was imported on 15th April 1907, dying a few days later, no rat mortality was noticed in connection with it. At about the end of December dead rats were found in this particular house and the first case occurred on January 23rd, 1908, followed by twelve others; no evidence of importation, and this village was the only one infected for many miles round. Interval about 8 months.

The above are cases where direct evidence of importation was obtained owing to the fact that the carrier of infection had contracted the disease, the case being reported. There is another and very important class of case to which attention must be directed where there is no such evidence but where importation is the only probable explanation although no human plague case has occurred in connection with the importation, and the first case reported is that occurring in the plague season following that in which infection was introduced. Such introduction may or may not on investigation be found to have been marked by rat mortality. Such cases as these greatly accentuate the difficulty of the problem of dealing with the disease by preventive measures, as epidemics originate in apparently healthy villages with no infection near at the time and where no active infection has been previously reported although it must have been present unobserved.

Case 29. Village Rayanwala, Naraingarh tahsil, Ambala district. There had never been any plague in this village before, but a neighbouring village Sahla, with which the inhabitants of Rayanwala have free communication was infected in the spring of 1907, the last case occurring on April 24th. Rat mortality was noticed in Rayanwala in May but no human beings developed the disease. Nothing further was noticed till October 15th when rat mortality again became apparent and the first indigenous case occurred on October 23rd. There was no evidence of importation to account for this autumn infection, and the only explanation that seems possible is that although no human case occurred importation was effected in the spring from the neighbouring village. The interval was some four or five months.

Case 30. Village Motaliwala, Muktsar tahsil, Ferozepore district. There was no plague in this village in 1906-07, but neighbouring villages were infected late in the spring. There were no signs of the disease until January 22nd, 1908 when a plague case occurred preceded by rat mortality for five days. No evidence of any importation and no connection with any infected village in the autumn. Interval indefinite but at least some 6 or 7 months.

Case 31. Mianwali district, except for a few imported cases not leading to epidemics, was practically never infected till the spring of 1907, when plague was imported into a village, Chokrala, and an epidemic followed causing 67 deaths, the last case occurring on 6th July; this was the only infected village during this plague season. Towards the end of April, 1908, the district being meanwhile absolutely free of plague since 6th July 1907, rat mortality was noticed in Kund, a village 3 miles from Chokrala, followed by the first case of plague on April 30th. There was no history of importation and no other infection anywhere in this part of the province. The only explanation appears to be that importation must have been effected in the early summer from Chokrala. Interval, at least nine months.

12. *Definite Connection between the two Epidemics.*

It is evident that the more limited an epidemic is in extent, the more likely it is that some connection in locality between it and the subsequent recrudescence of infection will be shown, and when an epidemic is widespread such connection will rarely be demonstrated. The best cases of all are those when the primary infection is limited to a particular house without any epidemic, such as cases 25, 26, 27 and 28 given above. Incomplete epidemics, and the smaller they are the better, often show connection fairly definitely.

Case 32. Village Mirchpore, Hansi tahsil, Hissar district, population 3,161. A case of plague was imported on 27th April, 1907, and 3 or 4 days after rat mortality was noticed; another case was imported on May 5th, and the first indigenous case occurred on May 13th, rat mortality spreading from the first house to those of the same mohalla. Only four more people were attacked, the last being on June 14th. About the 30th August rat mortality was observed to be occurring in houses attached to those infected in June, and the first case occurred on September 8th. This resulted in an epidemic of 624 cases, ending on 15th February, 1908. There was enormous rat mortality, but the case mortality was extraordinarily low, only 162 cases ending fatally. Interval $2\frac{1}{2}$ months.

Case 33. Village Narnaund, Hansi tahsil, Hissar district. Plague case imported on 5th June, 1907; a few days later dead rats were noticed in the house; a very slight incomplete epidemic followed resulting in 6 cases altogether, the last on July 26th. About the 7th September rat mortality

began in a house close to those previously infected followed by the first case on September 22nd. No history of importation or connection with infected localities. The epidemic ended on 19th April, with a total of 124 cases and 52 deaths, another instance of a low case mortality. Interval only 1½ months.

CASE 34. Village Chak Santal, population 916, Sialkot tahsil, Sialkot district. A plague epidemic raged here from 25th January to 4th May, 1907, resulting in 45 cases. Nothing further was noticed until the 2nd November, 1907, when a dead rat was found in a house where two women died in May, and the last dead rat of the preceding epidemic was found. Twenty cases and thirteen deaths. No history of importation and the first and only infected village in the district. Interval 6 months.

CASE 35. Sirsa town, population 17,058, Hissar district. This town was infected by importation on 2nd February, 1907, ninety-one cases occurring between that date and the 11th June; the epidemic was confined to one mohalla of the town. Nothing further was noticed until the 27th October, 1907, when rat mortality was noticed in a house in the same mohalla followed by the first case on 1st November. No evidence of importation. Rat destruction was at once carried out which probably accounts for the mildness of this epidemic which only resulted in 12 cases, the last on 15th January, 1908. Interval 4½ months.

CASE 36. Village Mirzapur, Hissar tahsil, Hissar district, population, 1,394. Infection imported on 7th May, 1907, 5 days later rat mortality was noticed, the second case occurring in the same house on 15th May; the epidemic was confined to a few Muhammadan houses, all having common walls with the first one infected, and only led to nine cases, the last on 6th June, rat mortality continuing for 15 days after this date. Nothing further was noticed until 24th November, when rat mortality again appeared in a Chamar's house which adjoins and has common walls with the Muhammadan houses infected in June, followed by first case in the same house on December 4th; rat mortality to a slight extent continued in this same block of houses but no further case occurred till late in January, 1908; it then spread throughout the village and caused 77 cases, the last on 13th April. Interval, 5 months.

13. *Recrudescence in separate parts of the same Locality.*

Granted that recrudescence is a fact, it might naturally be expected that cases would occur where signs of infection reappear, not in one particular spot from which it extends, but in two or more. Such cases do occur and afford very strong evidence in favour of recrudescence, for it is much more easy to imagine that the practically simultaneous reappearance of plague in separate parts of a town or village is due to such a cause than to simultaneous importation from some undiscoverable source.

CASE 37. Village Wiram, Chunian tahsil, Lahore district, population 923. Seventy cases of plague occurred in this village between 22nd January and 2nd May, 1907; nothing further was noticed until six cases occurred in different parts of the village practically simultaneously on 7th December, 1907. No rat mortality was observed but a bad smell, probably indicative of it, was noticed in the infected houses previous to the human cases. No further cases occurred. There was absolutely no evidence whatever of any importation, and there was no communication with any infected village. Interval 7 months.

CASE 38. Village Hudiala, Sharakpur tahsil, Lahore district, population 500. A case of plague was imported into this village on 5th February, 1907, no rat mortality was observed in connection with this case and there were no other cases. Rat mortality began about October 10th scattered about the village, with no definite connection with the previously infected house, and the first three human cases, November 1st, 7th and 9th, were in separate parts of the village and apparently quite unconnected with each other. No evidence of importation or connection with infected villages. Interval 8 months.

CASE 39. Village Butala Sharm Singh, Gujranwala tahsil, Gujranwala district, population 1,717. An epidemic causing eighty deaths occurred in the spring of 1907, the first case being on 2nd February and the last on 13th June. No further signs of infection until the 16th February, 1908, when two cases occurred on the same day, one in a house on north side, and the other on east, some sixty houses apart with no connection between the two. No evidence of importation or connection with infected villages, no rat mortality noticed. Interval 8 months.

CASE 40. Town Khudian, Chunian tahsil, Lahore district, population 3,401. An epidemic causing 85 deaths took place between 17th January and 14th May, 1907. Two cases of plague were imported in December, 1907, but no rat mortality or human cases followed in connection with them. At about the end of February rat mortality was noticed as occurring generally throughout the town and, on March 9th, human cases occurred simultaneously in three different streets and the epidemic began. Interval 9 months. The widespread nature of the reappearance of the disease in this case is indicative of recrudescence, in spite of the fact that importation had occurred previously; it must be admitted however that these importations may possibly have led to the subsequent epidemic.

It is interesting here to refer to case 7 above, where the off season was bridged by signs of active infection; in the village Manawala, the first two cases of the second epidemic appeared in separate

parts of the village with no connection, the third was connected with the second, while the fourth, fifth and sixth occurred in a part 300 yards distant from that first showing infection, with no apparent connection. This reappearance of signs of active infection in rat or man in a more or less indiscriminate way, in separate places apparently unconnected with each other, is very suggestive of recrudescence, and is very important for it differs widely from the definite extension from a particular focus which follows importation. In the latter case, importation into a particular house is communicated to the healthy rat population and then spreads along the line of least resistance to the inter-communication of the rat, down one side of a street, for instance, without crossing over, and through blocks of houses with common walls, so that the course of extension may often be fairly correctly predicted from a survey of the buildings of the locality; secondary foci may of course be started from the original infected area by importation into an uninfected part, but the connection can usually be traced without difficulty. There is often therefore a difference between the appearances of infections following recrudescence and those following importation, which makes it possible to be fairly certain that recrudescence has occurred, although, owing to the proximity of other infected villages, importation may be suggested. Although for the purposes of this investigation all cases where connection, even though remote, with infection rendered importation a possible factor have been excluded from the recrudescence class, many of these might have been classed legitimately as recrudescence on the grounds that have just been discussed. The case of the village of Dhand in the Amritsar district of the Punjab, which was under the close observation of the Plague Commission, may be appropriately referred to here.

This village, with a neighbouring one, Kasel, was suggested to the Commission as a place where plague would in all probability recrudesce. The last case in the previous epidemic occurred on July 14th, 1905. The village was carefully watched by the Commission from the end of November. No signs of infection were discovered until the 18th December, 1905, when the first chronic plague rat was captured; the first acute plague rat was found on the 27th January, 1906, and the first human case occurred on 6th February; nearly seven months after the previous case. The Commission remark that it is practically certain that no person suffering from or incubating plague arrived in the village before the epizootic began; that after careful inquiries they failed to elicit any information pointing to the disease having been introduced by healthy persons who had been exposed to infection elsewhere; that it was impossible to exclude this mode of origin as there was communication with Amritsar city which was infected; that the possibility of infection by migrating rats from elsewhere was excluded. They also remark that "the mode of "spread of the epizootic through the village was "characterized by considerable irregularity. It "cannot be said to have extended outwards from "the original focus as a wave with a definite margin, "leaving the area passed over free from infection "for the rest of the epizootic period."[1] They finally decide that the question of origin of the epizootic must be left unsettled. In my opinion the absolute want of evidence to show importation connected with the origin of the epizootic, combined with the fact of the irregularity of appearance of infection, is conclusive that this was but an instance of recrudescence that is so commonly occurring.

14. *Corroborative Evidence from earlier Epidemics.*

Even at this distance of time a brief study of the first epidemics in the Punjab, when the area infected was small and under close observation, will be useful. The history of the first importation of plague into the province is an interesting one, and this case belongs to the class where importation did not give rise to other signs of infection at the time, these appearing later after a considerable free interval.

Case 41. In the year 1897, Ram Saran, returning to his home from Hardwar, was taken ill at Rahon town in the Jullundur district on the way and eventually arrived, seriously ill, at his village Khatkar Kalan in the same district on April 28th, dying on the next day in his small mud-house near the middle of the village; his property passed to Hari Ram, a small shopkeeper living in the middle of the village. Nothing further occurred till the beginning of August when two persons were taken ill, Malan, dying on August 9th after eight days' fever, and her son Rana who died on September 13th with a history of fever and enlarged glands, but also of syphilis. There is no definite evidence that these were plague cases, but rat mortality was also noticed at the beginning of August, commencing in Hari Ram's cattle shed, which is close to Malan's house. In September, disease appeared among some Jats living near Malan's house and also among some Chamars occupying houses which adjoined, but had no direct communication with Malan's house and those occupied by the Jats, and there can be no doubt that these cases were bubonic plague although it was not until October when the disease, spreading more rapidly and frightening the people, was reported and so came to light. Interval 3 months. The subsequent epidemic 1897-98 was due to the spread from this focus by importation alone, recrudescence being of course absolutely excluded, and it is extremely important to notice that out of the total number of villages infected, 86, infection was traced in 72, or 84 per cent. Com-

[1] Page 91. "The Etiology and Epidemiology of Plague." Issued under the authority of the Government of India, Calcutta, 1908.

pare this with the 50 per cent. of the present investigation, where importation was a possibility, and in only half of which it was definitely traced. It was largely owing to the fact that, in districts which had previously been infected, it was difficult in many cases to account for the infection, as compared with those districts which were infected for the first time, that it was recognised that some other factor than importation was at work, and recrudescence began to be suspected. In the summary of the work of the Plague Commission, published by the Government of India, it is stated that a careful study of a Punjab district has shown that a history of possible importation could be obtained in 80 per cent. of the villages which became infected. In the case of a district previously uninfected, where the spread can only have been caused by importation, this is perfectly true, but in the absence of such qualification this statement is misleading, as the figures I have given show. The last cases of the epidemic of 1897-98 occurred in separate localities on June 3rd, 4th, 19th, 20th, and 23rd, and July 24th. The first case of the next season occurred about the middle of September in a previously uninfected village, and of the first eight villages attacked, the source of infection was traced definitely in one only, very indefinitely in two, and none was discovered in the other five; these latter had not been infected before, but it is significant that neighbouring villages had been attacked in the previous spring. The last cases of the 1898-99 epidemic took place on June 7th, June 23rd and August 15th. The first case of the next season which occurred on October 8th is interesting.

Case 42. Village Sahiba, Garhshankar tahsil, Hoshiarpur district, population 1,595. In April, 1899, infection was imported by clothing from an infected village and there were four cases between April 12th and 19th, the epidemic being effectually cut short by evacuation. The next case occurred on October 8th, and no evidence of importation could be obtained. On this case Major (then Captain) C. H. James makes the following remarks in his report on the epidemic 1899-1900:—"In the case of "Sahiba the question that at once arises in the mind "is, how did the disease get here? Had it remained "dormant since the previous spring and then again "become active as the weather became cooler, or had "it been introduced from another village? If the "latter, where had it come from? We could get no "evidence of the disease being imported. Indeed, "there were no villages infected for two months except Karnanan and this was at least 15 miles "away. The nearest villages to Sahiba, which had "been infected since its previous attack, were Jaipur "and Dial. But both these had been declared free, "the former on July 1st, and the latter on August "12th, and moreover have both since remained free "of the disease. We are, therefore, forced to the "conclusion that the infection had existed all along "in Sahiba, in some form or other, since the previous April."[1]

15. *Duration of the Interval of Apparent Freedom.*

The examination of the evidence for recrudescence that has just been concluded, has shown that an interval occurs between one epidemic and another and the cases given demonstrate that this interval varies from a very short one of a few weeks to a long one of many months.

In 112 cases taken, this interval between epidemics occurring in two successive plague seasons varied from a month and a half to fourteen months, the average being about 8 months:

From	2	to	$2\frac{1}{2}$	months	2
,,	3	,,	$3\frac{1}{2}$	,,	3
,,	4	,,	$4\frac{1}{2}$	,,	12
,,	5	,,	$5\frac{1}{2}$	,,	11
,,	6	,,	$6\frac{1}{2}$	,,	5
,,	7	,,	$7\frac{1}{2}$	,,	16
,,	8	,,	$8\frac{1}{2}$	,,	15
,,	9	,,	$9\frac{1}{2}$	,,	19
,,	10	,,	$10\frac{1}{2}$	,,	11
,,	11	,,	$11\frac{1}{2}$	,,	5
,,	12	,,	$12\frac{1}{2}$	,,	8
,,	13	,,	$13\frac{1}{2}$	,,	3
,,	14	,,	$14\frac{1}{2}$	,,	1

There is no doubt that had it been possible to continue the investigation into the spring the number of longer intervals would have been increased. Particularly definite instances of varying intervals are given in case 25, one and half months; case 27, four months; case 26, five months; case 28, eight months; case 15, nine months; and case 22, 10 months; in two of these the recrudescences occurred far from any other infection, and, in the others, the connection between the original infection and its subsequent reappearance is well established.

16. *Annual Recurrence.*

Granted the fact that recrudescence may occur after an interval of many months it would appear natural to infer that it might occur as an annual event in the same locality. Although the cases collected for the present investigation do not include any particular instances of this, as they only refer to two successive seasons, I may say that this appears to be an established fact in the Punjab and upon it is based one of the most important parts of our plague campaign, the attack on what have been termed endemic centres, *i.e.*, places where plague tends to recrudesce annually. It has not only been the experience of the special staff engaged that year after year the disease appears annually in certain places without evidence of re-infection by importation, but it is also recognised by the people themselves who will point to a certain village as the place where infection

[1] Page 2. "Report on the outbreak of Plague in the Jullundur and Hoshiarpur districts of the Punjab during 1899-1900," by Captain C. H. James, Lahore, 1901.

appears every year, and which leads to the infection of the villages of the surrounding area. The villages of Kasel and Dhand were selected for the Plague Research Commission as instances of this; Dhand, for instance, was first infected in May and June, 1902, six deaths; again November, 1902 to middle of March, 1903, 153 cases; after an interval of 11 months, from February to May, 1904, 376 cases; again after another plague free interval, April to July, 1905, 47 cases; the next February to May, 1906, 32 cases. The origin of the last epidemic could not be traced to importation, and, although definite evidence is not available on this point for previous epidemics, the village was selected because, in the opinion of the plague staff at the time, plague after the primary infection annually recrudesced there. Occasionally it is found that not only does plague recur annually in the same village or town but in a particular part of a village; for instance, in Manihala Kilpan, Lahore district, I find it noted that the first case of the 1907-08, epidemic occurred in a lane where it is notorious that plague makes its first appearance annually; the next two cases were at the other end of the same lane. In the Gurdaspur district, the annual epidemic begins almost every year in the same village, Bhagowala, as a recrudescence.

17. *Recrudescence after Longer Intervals.*

When it is considered that recrudescence may occur after an interval of twelve or thirteen months between the epidemics of successive seasons, it appears possible that the interval may be prolonged from one plague season to one two years later, one complete plague active season being passed in apparent freedom. In severe epidemics, where the rat population has been severely dealt with, the recrudescence may be delayed until quite the end of the following season, presumably because it takes a considerable time for the rat population to sufficiently recover from the effects of the previous attack, and the resulting epidemic is a very small one. Stretch this a little further and there would have been nothing but a slight epizootic without human cases to indicate that infection was present; further still, and there would be no apparent signs at all until in the third season the rats had sufficiently increased to make recrudescence possible. Cases of this sort though not common have occasionally been reported, but when it is remembered that importation may be effected at the end of a plague season giving no signs until the next, it will be evident that they are difficult to establish. This investigation is being continued, and as the province last season was remarkably free from plague, especially in certain districts, it is hoped that more definite evidence on this point will be available after the present season comes to an end. The district of Gujrat, for instance, was badly infected in 1906-07; in 1907-08 only two infections appeared, both recrudescences, unconnected with each other; it is here that one would look for definite evidence of recrudescence during the present season connected with some of the epidemics of 1906-07, if such is possible.

18. *Time of Appearance of Recrudescence.*

The following table shows the month of reappearance of infection in the 125 cases that have been collected during the season 1907-08. They have been divided into recrudescences following complete epidemics and those following incomplete ones:—

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.
Complete ..	3	5	5	5	9	12	32	14	6	2
Incomplete...	2	4	7	4	4	7	2	1	1	..

Not much value can be attached to these figures as the numbers are small, and especially because in only four districts was every infection investigated and in two of these, Mianwali and Gujrat, the infections were only one and two in number respectively. The investigation had to be dropped in most places in the spring as it was impossible to visit every infected locality, and the consecutive series had to come to an end; this is the principal reason why the numbers diminished in March and April; another reason is that the greater the number of infections, the more difficult it is to exclude possible importation. The figures however show to a certain extent what may be laid down as a rough and ready general law, namely, that given similar conditions, recrudescence following complete epidemics is more likely to be delayed till the spring, while those following incomplete ones are likely to appear in the autumn, and the more incomplete an epidemic is the earlier it will appear. The first signs of active infection in the autumn will, after those which have persisted throughout the summer, occur in those places infected late in the spring, and in those where importation has been effected without any resultant epidemic. The explanation of this is probably perfectly simple that the more severely the rat population has suffered during one season the longer it will take to recover and the later recrudescence will be delayed; in incomplete epidemics the epizootic has been checked by the hot weather, and a greater or less proportion of the rats remains unattacked until the favourable conditions of the autumn are reached. For the same reasons it may be said that recrudencences following incomplete epidemics tend to cause severe epidemics while those following complete ones will be mild.

19. *Is Recrudescence a general Phenomenon?*

It certainly is not. In Gujrat, for instance, recrudescence only occurred in two places out of a very large number, 884 towns and villages, infected during the previous season. Why this is so it is impossible to say. Why should plague recrudesce in one place and not in another with appa-

rently similar conditions? Why in one year and not in another in the same place? Doubtless all the factors which are favourable, or the reverse, to plague activity generally also operate with regard to recrudescence; temperature, humidity, the extent of flea prevalence, and rat infestation, all must have their effect. It is certain, however, that plague does not inevitably reappear in a place that has previously suffered, and numbers of villages are devastated by the disease which does not reappear there, unless a fresh importation is effected. It is, however, possible to say when and where recrudescence is most likely to appear; years that are favourable to plague activity generally are also favourable to recrudescence; it will occur principally during the seasons of the year when plague is most active, it will appear particularly in places that are very insanitary, and where the conditions are favourable to a large rat infestation and flea prevalence, and it is such places which are liable to an annual recurrence; the chances are in favour of recrudescence when the rat population has only been partially dealt with before the epizootic of the preceding season has been aborted by the hot weather. Finally it may be said that recrudescence is a much more common occurrence in the central and submontane districts of the Punjab than in the others.

20. *Rat Mortality in connection with Recrudescence.*

In the majority of instances rat mortality is apparent for some time before the first human case occurs. This is also true when infection is imported without the carrying agent suffering, but these cases are not numerous; as a rule the agent has contracted infection and is recorded as the first case *preceding* the rat mortality. It is this point particularly that first directed attention to the fact that some other factor than importation was operative in the production of the seasonal epidemic, for it was found that these cases, where rat mortality preceded the first case, were much more numerous in districts previously affected than in those attacked for the first time. Out of all the cases of recrudescence investigated a history of rat mortality preceding was elicited in about 75 per cent. Out of 129 cases, rat mortality preceding for from 2 to 7 days occurred in 55; from 7 to 14 days, in 32; from two to three weeks, in 18; for a month in 13, and for two months in two. In more than half the cases the rat mortality lasted from four to ten days before the first case, the most common period being ten days. The average period was twelve to thirteen days. Recrudescence is, therefore, commonly preceded by rat mortality evident to the ordinary villager. A history of rat mortality following after the last case in incomplete epidemics is sometimes elicited, as in cases 19 and 36.

21. *Recrudescence beginning as Pneumonic Plague.*

It sometimes happens that the first sign of recrudescence is a case of pneumonic plague in man, not preceded by any apparent rat mortality. It is, of course, impossible to say that rat mortality was not present and in some cases such mortality is actually observed. These cases appear to be of considerable interest. Are such cases primary pneumonic plague derived from some other source of infection than the rat, or can rat plague cause primary pneumonic plague in man, and if so, how? Or are these pneumonias secondary to a general infection, derived in the ordinary way from the rat, of such a mild type that the lung symptoms are the only prominent ones? Klein has found that partially immunized rats after being inoculated with virulent plague, may, although escaping the usual acute general infection, die after considerable intervals with marked lung symptoms.[1] I can offer no explanation but simply record some instances of a curious fact which seems to deserve further investigation.

Case 43. Anandpore, population 573. A suburb of the town of Pathankot, Gurdaspur district. 176 cases occurred here between the 11th November, 1906, and 10th April, 1907, the epidemic being originated by an imported case which was followed by rat mortality in the usual way. Nothing further was observed until the 25th August when a case of pneumonic plague occurred; the second case was also pneumonic and the next two bubonic, all occurring between the 25th and 30th August. No rat mortality was observed. No history of importation; no other infection in the district, this being the first place to report infection. Interval, four and a half months.

Case 44. Village Padri, Tarn Taran tahsil, Amritsar district; population 2,463. The last case of a very slight epidemic occurred on 27th April, 1907. Nothing further occurred till 1st February, 1908, when a case of pneumonic plague occurred in the person of a carpenter, living in a house infected two years before, the disease quickly killing him and all his family except his wife and then spreading to the rest of the village. No evidence of importation. No infected villages near. Rat mortality not observed but the reporting officer notes that it probably occurred. Interval, 9 months.

Case 45. Village Mattoo Bhaiki, Gujranwala tahsil, of the same district, population 1,179. The last case of an epidemic causing 57 deaths occurred on the 7th June, 1907. No signs of infection till 16th January, 1908, when a single dead rat was found in a house adjoining the one in which the subsequent case occurred, one of pneumonic plague on 20th January. No dead rats were seen in this house but it was noticed that the rats, which were very numerous, suddenly disappeared two or three days before the case. The second case was bubonic. No evidence of importation, no infected villages near. Interval 7 months.

[1] Pages 108, 109, 110. 'The Bacteriology and Etiology of Oriental Plague," Klein. Macmillan and Co., 1906

CASE 46. Village Papnakha, Gujranwala tahsil, of the same district; population 2,032. An epidemic resulting in 278 deaths ended on 10th May 1907. There was no apparent infection until nearly ten months later when two dead rats were found on the 4th March, 1908, in the house of one Maula Dad who fell ill of pneumonic plague on 14th March. The epidemic was slight, only twelve cases. No history of importation or connection with infected villages. Interval 10 months.

22. *Reappearance of Plague in the Same Individual.*

It is not at all an uncommon occurrence for plague to attack an individual for a second time, often in two successive plague seasons, and this must it seems be caused usually by a second reinfection from an outside source. Although it seems rather a far fetched hypothesis to imagine that infection may remain in the individual without causing symptoms for a time and then again become active, the following cases appear to be of interest whatever the explanation may be.

CASE 47. Qilla Sobha Singh, a small town in the Sialkot district. In this town lived Devi Ditta, a shopkeeper, and his wife Thakur Devi, their son Gandu and his wife Gopi, and the latter's two children, a boy and a girl. Two other sons of Devi Ditta's, Kirpa and Ram Ditta, kept a shop in the neighbouring village of Charwind. In 1901, Kirpa contracted plague at Charwind and came to his father's house at Qilla where he died on December 7th; his effects passed to Ram Ditta. Ram Ditta was attacked on 1904 at Charwind, went to Qilla and died in the house there on April 15th; both his own and his brother's property passed to the Qilla family. In 1905 Devi Ditta was attacked, dying on 13th April. In the spring of 1907, all the remaining members of the family were attacked (source of infection not elicited); Thakur Devi died, Gandu and his wife recovered, the boy recovering and the daughter dying. This left 3 survivors of the family all of whom had been attacked by plague. At the end of 1907, Gandu, who had suffered from plague with right inguinal bubo in the spring of the same year, again developed the disease with cervical bubo, dying on the 1st January, 1908. No infected villages near and no history of importation. No rat mortality was observed. It was the only case in the town.

CASE 48. Loddi Jajja, a village in the Sialkot district, visited by plague for the first time in 1907, twenty deaths occurring between 1st June and 15th July. The interest centres in a particular house in which lived thirteen people; of these eight were attacked with plague in this epidemic, four of them dying. Nothing further was heard from this village till January when plague was reported. On investigation, it was found that two suspicious cases of deaths from fever had occurred in September, and six in October; of the latter, one was Nathu, the father of the family in question who had suffered from plague in June; he is recorded as having died on October 27th, after four days' fever, and the investigating officer notes that in his opinion he almost certainly died of plague. The first case of the next epidemic that was reported was Hyat, of the same household, who had also suffered from plague in June; he died of plague on 17th January, 1908, after a few days illness. There was no rat mortality observed and no possible history of importation. It is curious to note that, in this household, of those surviving tho June epidemic of 1907, *viz.*, four recoveries and five unattacked, five get plague the following season, and these were the four recoveries, two of them dying, and only one of the five unattacked. Dr. Lewis Jones, referring to another instance (record unfortunately lost) of a village Wahlianwali, where plague appeared in a house after the arrival of a new wife who had suffered elsewhere from plague during the previous season, remarks: "My experience in the three villages where plague has broken out in my area of work this year is that the individual is to be suspected more than the house in which he resides."

CASE 49. Village Jhandeake, Hafizabad tahsil, Gujranwala district. An epidemic ending on 30th April, 1907. No further signs of infection until 14th February, 1908, when a woman who had been attacked the previous April, developed symptoms of plague with an axiliary bubo, dying after 15 days. There was no rat mortality observed, no connection with infected villages and no history of importation. Only one other case occurred.

23. *Summary.*

In the examination of the figures, and instances, which has now been completed, it has been shown that—

(*a*) Continuous signs of active infection remain in a few places in the Punjab throughout the period of abatement and definitely connect one epidemic with the following one.

(*b*) The hot weather interval is occasionally marked by sporadic signs of infection in rat and man.

(*c*) Such infections (*A* and *B*), however, only constitute a small part of the origin of the annual widespread visitation.

(*d*) Recrudescence of plague occurs in a very considerable number of cases, after an interval during which no signs of infection are apparent.

(*e*) This interval between the epidemics of two successive plague seasons varies from quite a short one to one extending to many months or even a year.

(*f*) Recrudescence may possibly occur after a still longer interval including a complete plague season.

24. *General Laws.*

Although it must be admitted that the factors governing recrudescence are but imperfectly understood, it is possible to postulate from past experience certain general laws.

(*a*) Recrudescence tends to appear early the next season in those places which have suffered only incomplete epidemics in the previous one, that is to say, where the epizootic has been cut short by the hot weather before affecting the whole of the rat population.

(*b*) An incomplete epidemic is not a necessary precursor, for importation may be effected late in one plague season without any epidemic or even any signs of epizootic until, after an interval of apparent freedom, recrudescence occurs.

(*c*) Recrudescence following complete epidemics, where the rat population has been completely dealt with before the hot weather, more generally appears late in the following plague season, presumably because time for the recovery of the rat population is necessary.

(*d*) The severity of the epidemic accompanying the recrudescence will vary directly with the incompleteness of the previous one; the less the rat population has been affected during the first epidemic the more severe will be the following one.

(*e*) Generally, therefore, recrudescence occurs earlier and is more severe after incomplete than after complete epidemics.

(*f*) The more insanitary a locality is the more liable it will be to recrudescence. The reappearance of infection usually occurs in the most insanitary part of a locality, in houses, dark, damp and ill ventilated. Briefly, all conditions favouring rat and flea infestation are favourable for recrudescence.

25. *The Practical Importance of the Subject.*

It is the fact of recrudescence that makes the plague problem so difficult in the Punjab; were it true that each yearly visitation originated in those few places where active infection remained during the hot weather, it would be comparatively simple, for all effort could be concentrated on such places, and, in my opinion, it would be perfectly legitimate and easy to employ compulsory measures if necessary to attain the desired end. It is perfectly evident, however, that, successful as such measures might be in preventing these infections from spreading, they would in no way prevent the annual recurrence by recrudescence which is continually occurring throughout the plague season in places which have been apparently free for some time. each of these forming a focus from which the disease spreads by importation into unaffected localities. It is therefore imperative to obtain all the knowledge that is possible with regard to recrudescence, so that the dangerous places may be located with certainty and so treated that a recurrence is prevented. In the Punjab this is our first and perhaps the most important line of attack, but the facts given in this paper will have made it evident how difficult it is to make it an effective one, although recrudescence is not by any means a general phenomenon. We have practically to consider not only all places infected the previous season as possibly retaining infection, but also places previously apparently unaffected where importation may have been introduced. For complete success it would be necessary to attack every town and village in the greater part of the province so as to extinguish every potential centre; all that can be done at present is to attack those which are considered most dangerous leaving the others to be tackled after infection has become evident and the epidemic has begun, when there is little chance of suppressing it and preventing the inevitable spread.

26. *The Need for Further Investigation.*

In "The Etiology and Epidemiology of Plague," a summary of the work of the Plague Commission, issued by the Government of India, the eighth conclusion arrived at is that the non-epidemic season is bridged over by acute plague in the rat, accompanied by a few cases in human beings. Moreover, it is stated that in the Punjab "the non-epidemic "season is bridged over by acute rat plague accom- "panied by a few human plague cases in the towns "and villages, the disease being kept in check by "one or other of the factors which, as we have al- "ready shown, act in this manner. When the con- "ditions, which are suitable for the rise of the epi- "zootic, become established, the disease rapidly in- "creases in the places where at that time it was "present as acute rat plague, and then spread out- "wards from these foci by the conveyance of infected "rat fleas from village to village, these fleas being "the starting point of the rat epizootic in the unin- "fected villages."[1] The facts that have been cited in this paper, in my opinion, contradict this view, and it has been, I submit, conclusively shown that signs of active infection are apparent in but a few places throughout the non-epidemic season and that such places are a very small part of the origin of the next seasonal epidemic. Two villages were handed over to the Commission for investigation where it was considered probable that recrudescence would occur; in one of these, Dhand, plague reappeared, with no evidence of importation to account for it, after an interval of apparent freedom from acute plague in rat or man lasting for more than six months, during part of which interval, from 29th November 1906 to 27th January 1907, the village was under the close observation of the Commission and a large number of rats examined without finding any signs of acute plague. In the other village, Kasel, importation was possibly effected from Dhand. In the face of these facts, obtained by the Commission itself in the only places investigated in the Punjab, it is difficult to understand on what grounds such a statement as that quoted above has been made.

A glance at the total weekly or monthly figures for the Punjab shews that plague is practically

[1] Page 91. "The Etiology and Epidemiology of Plague," Calcutta, 1908.

present throughout the year, and without a knowledge of the actual facts it is easy to assume that each annual epidemic arises from the spread of infection by importation from those places remaining infected at the end of the previous one. A more detailed study of the figures and an investigation of the first cases of the seasonal rise completely disposes of any such assumption. The hot weather break in 1908 was more marked than usual, and in the table given at the end of this paper shewing the weekly number of cases reported in each district, the division between the two epidemics is plainly shewn; the last cases of the 1907-08 epidemic occurred in the week ending July 25th, the next cases, two in the week ending August 8th, were, in both instances, recrudescence; one, accompanied by rat mortality, in Karnal town, where there had been no plague since the end of April; the other in the Civil Lines of Lahore, near which there had been no cases for many months; in neither of these was there the slightest evidence of importation of infection. Plague next appeared in the Ludhiana and Ferozepur districts, where recrudescence appeared rapidly in a number of villages in the same area, in which may be also included Patiala, a Native State. Successive maps of this area would strongly suggest that the spread of the epidemic was due to importation from the first place shewing infection, but investigation proves that it was not so, and that, on the contrary, it was due to recrudescence occurring in a number of places in the same area. In the remaining districts shewing infection, the reappearance, with one exception Hissar, was *in every instance* due to a recrudescence unconnected with the epidemics proceeding at the time in others, and it will be seen that the interval was quite a long one in Jhang, Gujranwalla and Shahpur; in Hissar, the four cases were imported. Little value, therefore, in my opinion, can be attached to conclusions based on mere collections of figures or on maps that are not checked by detailed examination and reference to actual facts. Out of the first 74 cases of the 1908-09 epidemic, in fifty the reappearance of plague was due to recrudescence and in only 24 was importation definitely traced or thought to be possible. How then is the interval between two epidemics, which may extend to many months, bridged? It is possible that acute plague can continue in the rat over long periods of time to such a small extent as not to be evident?

It is possible that it may be so, and in case 6 it is known to have continued in connection with one particular house, shewing that acute rat plague may continue at a very slow rate of progress for a considerable time. No such acute infection, however, was found in Dhand by the Commission for two months. Can chronic plague in the rat be ignored as a mere pathological curiosity? The recrudescence of plague in places apparently free from infection for a considerable time, is an established fact in the Punjab, of common occurrence and of the utmost importance from the point of view of those engaged in dealing practically with the epidemic. I think these questions require consideration, and I recommend them as subjects for further investigation.

Statement showing the number of Plague Cases reported each week from British Districts and Native States in the Punjab during the half-year, June to November, 1908.

(End of 1907-08 Epidemic in ordinary figures, beginning of 1908-09 Epidemic in italics.)

Week ending—	June 6th.	June 13th.	June 20th.	June 27th.	July 4th.	July 11th.	July 18th.	July 25th.	Aug. 1st.	Aug. 8th.	Aug. 15th.	Aug. 22nd.	Aug. 29th.	Sept. 5th.	Sept. 12th.	Sept. 19th.	Sept. 26th.	Oct. 3rd.	Oct. 10th.	Oct. 17th.	Oct. 24th.	Oct. 31st.	Nov. 7th.	Nov. 14th	Nov. 21st.	Nov 28th.	REMARKS.
Hissar	1	2	..	..	..	..	..	..	..	..		..	..	..	..	..	..	..	..	..	**4*	..	..	..	..	..	*All imported,
Rohtak	..	6	4	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*10*	..	..	..	..	Recrudescence.
Gurgaon	11	11	7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.	..	..	..	..	..	
Delhi	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Karnal	50	8	6	55	3	..	..	..	..	*1*	..	..	..	..	..	..	..	..	..	..	..	*2*	*1*	..	..	..	Recrudescence.
Ambala	6	6	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*2*	..	..	Ditto.
Hoshiarpur	17	18	4	1	2	3	..	..	..	..	..	..	*6*	*2*	..	*1*	*1*	*4*	*3*	*2*	*1*	*2*	*3*	*15*	*30*	*53*	Ditto.
Jullundur .. .	6	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Ludhiana	162	67	18	2	1	2	..	..	..	..	..	*3*	*15*	*26*	*34*	*57*	*35*	*65*	*38*	*60*	*39*	*90*	*39*	*80*	*23*	*52*	Recrudescence.
Ferozepore	106	48	16	2	..	..	..	..	..	..	..	..	..	..	..	*12*	*16*	*13*	*13*	*36*	*61*	*69*	*77*	*124*	*95*	*128*	Ditto.
Montgomery ..	14	6	2	2	1	..	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	*9*	*1*	..	Ditto.
Lahore	156	115	60	46	23	3	3	4	..	*1*	..	..	..	..	..	..	..	..	..	*8*	..	..	..	..	*18*	*35*	Ditto.
Amritsar	30	27	7	7	2	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Gurdaspur	8	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	*..	..	..	..	..	..	*Dead rats noticed in the village where plague first appears annually.
Sialkot	3	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Gujranwala .. .	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*2*	*1*	*8*	*6*	*2*	*5*	*20*	*24*	Recrudescence.
Gujrat	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Shahpur	18	..	..	..	..	..	..	.	..	..	..	..	..	..	..	.	..	..	*11*	*1*	*4*	*2*	..	*5*	*6*	..	Recrudescence.
Jhelum	10	2	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.	..	..	..	
Rawalpindi	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.	..	
Attock	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Mianwali	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.	..	.	
Lyallpur	57	13	8	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*7*	*7*	*1*	*8*	*8*	*2*	*4*	*24*	Recrudescence.
Jhang	20	..	..	..	..	..	..	..	..	.	..	..	..	..	..	..	*19*	*36*	..	*14*	*8*	*8*	*4*	*6*	*5*	*5*	Ditto.
Native States. Patiala ..	70	48	88	2	2	..	..	..	..	..	..	..	..	..	..	*28*	*28*	*80*	*30*	*22*	*24*	*129*	*200*	*210*	*70*	*165*	No details.
Native States. Jhind ..	4	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	*10*	*10*	*6*	*1*	Ditto.
Native States. Nabha ..	11	4	..	.	..	..	..	..	..	..	..	..	..	..	..	.	..	..	.	..	.	..	*4*	*9*	*15*	*24*	Ditto.
Provincial Total ..	777	895	234	124	35	8	4	6	..	*2*	..	*3*	*21*	*28*	*34*	*98*	*99*	*198*	*104*	*151*	*150*	*326*	*348*	*477*	*293*	*511*	

DISCUSSION.

Major Lamb said :—All workers on plague problems and especially those in India are deeply indebted to Major Browning Smith for bringing up for discussion the important question of the cause of the origin of the annual outbreaks of plague in the villages of a district such as the Punjab. As he has pointed out, on the solution of this problem depends the prophylactic measures which should be recommended to Government. On the one hand, if the annual epidemics in the villages owe their origin in the vast majority of cases to recrudescence of the disease, that is to say, to a lighting up of remnants left over from some previous epidemic, it would be almost impossible, in the present state of affairs, to devise practical prophylactic measures which could be relied on to bring to an end or even to limit the devastations of the disease.

If, on the other hand, the great majority of villages in a district owe the origin of the annual outbreak to fresh importation from some previously infected locality, the bridge-over of the quiescent period being brought about by the infection surviving as acute rat plague in only a very few towns or villages, then the chances of at least limiting the annual outbreaks by well thought out measures would be great, so great as to justify a responsible Government in carrying them out as strictly as was consistent with the maintenance of good relationship between the people and their administrators.

The problem, then, resolves itself into whether the great majority of villages owe the origin of their infection to recrudescence or importation. While Major Browning Smith has attempted to solve this problem in one way, the Plague Commission have attacked it in quite another manner. Major Smith's conclusions are now before us, while the data obtained by the Commission have led to conclusions which will in due course be published. I would, therefore, ask the readers of Major Smith's paper to suspend their judgment until the results of the Commission's work are before them. I would ask them to be the more cautious in this matter both because the Commission's conclusions are opposed to those of Major Smith and because great objections, as I propose now to show, can be taken to the nature of the evidence on which the very definite conclusions formulated by Major Browning Smith are founded. Let us for a moment look at these conclusions and at the data on which they depend.

Major Smith comes to the conclusions, that recrudescence of the disease from remnants left over from a previous epidemic is the cause of the origin of the outbreak in a very considerable number of villages (at least 45·5 per cent.) after an interval during which no signs of infection are apparent : that this interval between the epidemics of two successive plague seasons varies from quite a short one to one extending to many months or even a year, and that recrudescence may occur after a still longer interval including a complete plague season. He is further of opinion that importation plays only a small part in the origin of the annual widespread visitation.

How has he arrived at these most important conclusions? During the epidemic of 1907-08 an attempt was made by the district plague officers in the Punjab working under Major Smith's directions to trace the origin of the epidemics in the case of 277 villages in certain selected districts. The circumstances of each case were personally inquired into by these officers, the inquiry, I gather, not taking place until after the first plague case was reported. No attempts were made to examine the rats, the whole evidence being obtained by questioning the village officials and the inhabitants as regards rat mortality, the occurrence of plague cases and possible importation. The infected villages in the district and in other districts of the Punjab were of course known.

As a result of these inquiries the 277 villages were divided into 5 classes as follows :—

(1) Villages in which the evidence pointed to signs of acute infection persisting throughout the quiescent period and connecting one season's epidemic with the next (4 p.c.).

(2) Villages in which the evidence pointed to the infection being imported by a human plague case (18·8 p.c.).

(3) Villages in which definite evidence was obtained of importation in clothes or property, the human agent himself not being infected (6·5 p.c.)

(4) Villages in which no definite evidence of importation could be obtained, but in which communication with an infected locality was possible (25·2 p.c.)

(5) Villages which did not fall into any of the above four groups. In the case of these villages Major Smith considers that the absence of evidence of bridging over by acute infection and of importation sufficient to warrant him in coming to the definite conclusion that importation did not take place and that the origin of the epidemic was from remains left over from a previous epidemic, no matter how far distant. Out of the 277 villages 126 fall into this group (45·5 p. c.).

These are the data on which Major Smith bases his case for recrudescence. It seems to me that the evidence is of the weakest description and that therefore the conclusions are not justified.

First, it is clear that, when one has to depend on evidence of the nature mentioned above, the agency by means of which the investigations are made and the habits of the people are of the greatest importance. Much must depend on the thoroughness and patience with which the inquiries are prosecuted ; concealment of movements would no doubt be common by a people of a different race to that of the investigator, this factor depending on the knowledge the people had of their inquisitor, on the amount of confidence which he inspired and the sympathy he showed. When we examine Major Smith's own figures we see that there is probably considerable fallacy from these sources. Thus, in the Hissar district, out of 42 villages investigated only 9 (21 p. c.) fall into the group of recrudescences, while, in the Lahore district, out of 39 villages 28 (72 p. c.) are put into this group. Surely such an enormous difference as this can only be explained on the grounds suggested above. Secondly, we must ask ourselves the question if Major Smith is justified in coming to the conclusion that, if his agents failed to get a history of importation and if the villages in the neighbourhood were not infected, the origin of the outbreak was certainly due to recrudescence. In other words we are asked to accept the failure to prove importation as certain evidence of recrudescence. I am afraid Major Smith will get few to agree with him on this point, and I for one cannot too strongly dissociate myself from such a view. Let us, in this connection, consider for a moment the question of importation and the difficulties surrounding its demonstration.

The Plague Commission have pointed out, and no one has refuted them, that importation into an uninfected locality takes place nearly always by means of infected rat fleas, which are as a rule carried in by human agency, in clothes, bedding, etc. of persons coming from a plague infected house. The human carrier may or may not himself be plague infected. Infected fleas thus introduced at once take to their natural host, the rat, and, infecting it, start the epizootic. After the epizootic comes the epidemic. But it is certain that, as a rule before the first plague cases occur, that is to say before the village is reported as infected, the epizootic will have been in progress for some time. There must, therefore, be in the majority of instances a considerable interval between the importation of the infected fleas and the beginning of the enquiries to trace the origin of the outbreak. This interval would be at least a fortnight and of course might stretch out to two or three months. Major Browning Smith himself records periods of from 2 weeks to 2 months during which there was an apparent rat mortality before the human cases began. Under these conditions of investigation I ask any one who knows the native of India and the circumstances of life in a Punjab village, if he would accept as positive evidence of recrudescence the failure to obtain a history of importation. It is in this connection to be remembered that infected fleas may retain their power of infection for fifteen days at least and that they may live for several days

without food. They may, therefore, in these days of railways, quick travelling and greatly increased intercourse between villages and large centres, be imported from some considerable distance, so that it is no argument against importation to show that no villages in the immediate neighbourhood were infected. During the plague epidemic in the village of Kasel, while it was under the close observation of the Commission, there were no less than four cases of plague which received their infection elsewhere. None of these came from neighbouring villages, one even from quite another district, namely, Lahore. Again the first village to be infected in the Punjab was far removed, hundreds of miles from the nearest plague infected locality. It is, therefore, absurd to limit the distance over which importation can take place. Again it is more than likely that a man, in whose house rat mortality began, would, when enquiries were being made a month after the event, conceal the fact that he or some of his family had come from a plague infected locality. It is possible that importation may have taken place by a casual visitor whose sojourn was of short duration. It is also possible that the infected fleas might be imported in grain, merchandise, or without direct human agency. In short, one can imagine so many possibilities, so many ways by means of which infected fleas might be imported into a village, ways which it would be impossible to trace, that one marvels that the failure to correlate such importation and the origin of the outbreak would satisfy any one that importation had not taken place. I, for one, cannot accept such evidence as proof of recrudescence and I am therefore forced to discard Major Smith's conclusions, which as I have said are based entirely on the assumption that if no history of importation could be traced, or no evidence of a complete bridge over could be obtained, the origin of the outbreak must be due to recrudescence. In this connection I have to point out that Major Smith himself states that in the case of some villages which had never been infected before it was not possible to trace the origin of the infection, which of course must have been due to importation. Thus he tells us that, in the case of eight villages which had never been infected before, the source of infection was traced definitely in one only, very indefinitely in two and none was discovered in the other five.

As I have now shown that Major Smith's data are unreliable, the method of obtaining them being at fault, it is unnecessary further to consider his paper, all his conclusions being founded on these data. While, then, I would ask you not to accept these conclusions, I am not at present in a position to put forward the evidence obtained by the Plague Commission. I can only say that it is founded on data obtained from a study of all the epidemics which have occurred in certain districts of the Punjab and United Provinces, and is of the most exhaustive character. As I have already said our conclusions are different from those of Major Smith and point to the origin of the outbreak in the great majority of villages being due to fresh importation. There will in consequence be some hope of limiting the number of villages infected by limiting the chances of importation.

Dr. Turkhud said :—While carrying on investigations last year in the Satara District into the epidemics of plague for 1907 and 1908 in the Walwe Taluka which is generally badly affected by plague every year, I came across no cases of "recrudescence," *i.e.*, in no villages was plague found to reappear without fresh importation.

The following are the results of careful enquiries into upwards of 50 villages :—

The first cases of plague shown in the Village Registers were not generally the actual first cases of plague.

The actual first cases of plague occurred earlier, and were not reported as plague, but put down to various other causes such as "fever," "9-day fever or pneumonia," "asthma," "diarrhœa," &c.

This inaccurate information given in the village registers was not always supplied intentionally, but was due, in some instances, to mistaken diagnosis on the part of the deceased's relatives, who are apt to cling to the notion that the sickness is not plague if there be no outbreak in the village.

There is generally some reluctance on the part of the people to admit the presence of the epizootic among rats.

Two epidemics shown in some of the villages were found upon enquiry to be actually one continuous epidemic, the presence of plague during the so-called interval not being detected and reported.

Some villages showed as many as 10 imported plague cases before indigenous cases of plague commenced to occur in them.

An increase in the death-rate of a village was generally noticed long before the so-called first case of plague was shown in the register, and some of the suspicious deaths that had taken place during this period when enquired into were readily admitted by the people as due to plague.

An increase in the general mortality was sometimes noticed in some villages during the off season, and although the village officers reported no plague, careful enquiries carried on in such villages have often revealed the presence of plague.

The Village Officers are rather apt to declare this village free from plague before it is actually so, and are reluctant to admit its presence until the disease assumes an epidemic form.

If a village was evacuated on account of plague the fact must be also taken into consideration before one could definitely come to a conclusion whether there were two epidemics in the village with an interval, or one continuous epidemic. Evacuation exports a number of plague cases to other villages. Early return brings on what might appear to be a second epidemic, while in reality it was only a continuation of the first.

The infection of plague may be conveyed into a village from even a very long distance.

The importation of the infection of plague into a village was always found to have taken place through human agency.

Sometimes additional fresh importations of infection occur while an epidemic of plague is actually going on in a village.

Same villages and "wadi," *i.e.*, hamlets under villages, have been found to show persistence of plague in them even during the non-plague season.

Enquiries into the previous years' mortality have shown that plague is not endemic in these villages but imported there from elsewhere.

Such villages showing persistence of plague during the off-season are likely to become the starting points of outbreaks of plague in other villages.

Such villages, therefore, should be specially found out, and every effort made to stamp out the infection in them.

One of the ways of ascertaining this is by making careful enquiries into the causes of deaths in every village showing, during the off-plague season, an excess of monthly mortality above 25 per mille per annum as calculated from the census of 1901. This percentage is found to work well for the Satara District. Of course the existing population is considerably below the census of 1901.

The residents of a village as well as the Village Officers are generally averse from admitting sufficiently early the existence of plague in their village, and prefer to wait for the plague to assume an epidemic form before declaring it.

This can however be remedied by adopting a method of subsequent verification of deaths, by establishing a regular staff of circle Inspectors who will also thus be able to find out the villages showing the prevalence of plague during the non-plague season.

REPLY.

Major Browning Smith said :—The fact of recrudescence was unexpected and consequently was not looked for, and I cannot therefore be accused of preconceived ideas which I have endeavoured to prove ; it is a fact that the constant iteration of experience has almost forced it upon me against my intelligence.

My case is not, as apparently Major Lamb conceives it to be, a case of Recrudescence *versus* Importation ; the point I

urge is the importance of recrudescence because, if we could prevent it in the Punjab, plague would not reappear and consequently the question of importation, unless from outside the province, would not arise.

The percentage of recrudescenses, 45 per cent. in the districts investigated is undoubtedly high ; I have not suggested that, in every year in all districts, the proportion would be the same, and I explained that, in the particular case given, the season was particularly favourable for the investigation because local epidemics were mild and, consequently, the importation factor was not operating so strongly as in a year when epidemics are severe ; this factor varies directly with the severity of plague incidence.

My critic remarks that it would be absurd to limit the distance over which importation can take place. I entirely agree, but I would add that importation is more common over short distances than over long. I would remind him that infection was first introduced into the Punjab in 1897, and that the second introduction from the outside did not occur until 1901, although Bombay and other places were badly infected during this period.

Major Lamb gives two instances of the fallacy of my argument, and I think he has been unfortunate in his selection, for a reasonable attention to what I have written would have shown him that they are both in my favour. In the first place, the variation in figures in the Hissar and Lahore districts is not a discrepancy at all, but is explained by the fact that, in the southern districts, recrudescence is less common than in the central ; this point is referred to in para. 19 ; Hissar is in the south and was selected on this account, Lahore is in the centre. The second instance is the case given of eight villages which were first infected in the second annual epidemic ; none of these had shown infection before and importation was traced in one, possibly in two, and in the other five the source of infection could not be discovered (para 14) ; Major Lamb dogmatizes that *of course it must* have been importation, and I may perhaps be allowed to ask why ; allowing for the fact that in a minority of cases importation, although effected, cannot be traced, in my opinion the majority of these five infections must be explained by the importation of infection at the end of the previous season, active signs not appearing till the autumn after a latent period. (*Vide* para. 11).

The next point to be dealt with is the difficulties of the investigation and the possibilities of error. I have yet to learn that, because an investigation is difficult, data obtained most necessarily be incorrect, and I would ask Major Lamb to consider that the enquiries were carried out by qualified Medical Officers of intelligence, with knowledge of the methods of extension and the ætiology of the disease, experienced in Plague work and, moreover, from their work in the district, familiar with the people, their language and customs ; in addition I would point out that this special investigation was only undertaken after the gradual accumulation of many years of observation.

With regard to the objection that inquiries were conducted some time after infection had appeared, I submit that it could not be otherwise : Major Lamb however is perfectly aware that masses of figures from the Punjab have been and are being used by the Research Commission, figures referring to infection of distant date that has never been investigated at all ; perhaps he may be able to explain why they are to be accepted in one case and not in another.

I have now dealt with the objections that have been raised, and I consider that the arguments used by Major Lamb do not in any way attack the position I have taken up ; it is on the strength of such arguments however that he has stigmatized the data as unreliable and the method of obtaining them at fault, and has condemned the conclusions as not being justified.

Although I am convinced of the essential truth of the facts I have put before you, I certainly admit that there must be a margin of error, but I am equally convinced that these facts cannot be contemptuously set aside on the mere *ipse dixit* of any one, however distinguished he may be.

To those who are interested in the subject, I would commend a careful study and a comparison of the way plague spread originally over the Punjab by importation, and the way it reappears annually now ; no greater contrast could possibly be found. Plague, originally imported from Hurdwar, was confined to a small area in the centre of the Province for some three years or more ; a second lodgment was then effected into another part and, with the inevitable abandonment of compulsory measures, the epidemic began its natural spread over the country. This spread was in the nature of a gradual extension from a centre, from one district to an adjacent one, geographical obstructions such as large rivers forming a considerable bar to its progress ; it took years for the epidemic to cross the Jhelum river on the north, and a long time also to penetrate to the southern districts. Contrast this with what has occurred in 1908, where has plague appeared since that time in the summer where active signs of infection had practically disappeared ? At the present time it is present in sixteen districts although the total number of cases reported does not much exceed five hundred a week ; its first appearances have been almost altogether in small villages widely separated from each other, and unconnected by railways and main roads ; only one town of any considerable size has shown infection. Having made this comparison I would ask the following question which appears of some pertinence. Are we to suppose that the spread of epidemic plague has entirely altered in character, and to accept this without any attempt at explanation ? In my opinion the facts cannot be explained away by simply stating that infection has been overlooked in the large towns and in villages on the way from these to the remote ones where infection was first discovered.

This striking contrast I offer to Major Lamb for consideration, and ask him if it is to be ignored as unworthy of any attempt at explanation ; it is of the utmost importance that this striking duration should be accounted for. To us, workers in darkness, engaged in the actual fight with the epidemic in the field, the light that has been shed on the ætiology of plague by the works of the Plague Research Commission has come as an immense help, but, in my opinion, more is required and the last word has not yet been spoken.

I did not expect any immediate acceptance of the views I have promulgated to-day, and all I ask is that the subject should be investigated on the spot by the Commission ; I can promise that we shall give them all the facilities and help that we can. Then, if I am proved to be wrong, and not till then will I recede from the position I have taken up.

In conclusion, I refer once more to the statements made by Major Lamb in the summary of the work of the Commission which I have quoted in the concluding paragraph of my paper and affirm that it is not supported by the observed facts.

THE RACES OF INDIAN RATS.

By Capt. R. E. LLOYD, M.D., I.M.S.

The bearing of the Enquiry on Plague Dissemination.

Since it has been recognised that rats are important factors in the dissemination of plague, the attention of many has been turned towards these rodents. In consequence, it became evident that we knew little of the distribution of their several races in India, and that some of the statements, hitherto accepted in regard to them, must be looked upon doubtfully. It was shown that mole-rats, which were considered solely as dwellers

in the fields, could in some circumstances become intimately associated with man, while in other circumstances house rats might establish themselves in fields. Doubt was felt as to the extent to which the wandering grey-rat (Mus decumanus) prevailed in India. It was shown that the races of rats infesting Calcutta and Bombay were remarkably different from one another, so that it became desirable to compare them with those of other ports. The present enquiry is an attempt to throw light on some of these questions.

The extermination of rats has been largely carried out in many districts in India, as a means of directly diminishing plague mortality. Such measures are perhaps partly of an experimental nature; the question of their efficacy cannot be discussed here, it is one for sanitary science to deal with. It was clear, however, that this attempted rat extermination provided an opportunity of gaining information, regarding the distribution of the various kinds of rats throughout the country, since large numbers of them could be collected from different localities and compared: from this comparison information of direct or indirect practical importance might be gained.

It has been kept well in view that to obtain such information is the purpose of the present enquiry. Although the practical value of the information may not seem great, it is hoped that the facts themselves will be of suggestive value to those more acquainted with the ætiology of plague than the writer.

A Comparison between Rats found in the Ports of Bombay, Calcutta, Madras, and Rangoon.

This question is of importance, for as a rule the sea ports are the doors by which the infection of plague enters a country. In all probability plague entered the Bombay Presidency and Upper India by the port of Bombay, and it certainly entered Burmah through Rangoon.

In comparing the rodents of the four great ports, one important fact stands out. Mus decumanus is common both in Bombay and Calcutta. It is present, but not common in Rangoon, it is absent from the city of Madras.* There must be a definite cause to account for this. There is another peculiarity in the rodents of Madras. The bandicoot is very rarely found in Bombay, it is uncommon in Calcutta, where it is occasionally found burrowing near the numerous tanks of that city. It is absent from Rangoon, a smaller sort of bandicoot being common there. In Madras, however, the large bandicoot is so common that the populace can kill as many as 100 of them daily, although it is too large to enter traps and has to be killed by blows from sticks. The Madras bandicoot is an outdoor rat, a dweller in drains and outhouses, having a total length of about two feet; it would not be tolerated in the houses, where it could not move without detection. Its mode of life is therefore essentially the same as that of Mus decumanus. The rodent fauna of Madras is therefore peculiar in two ways,—in the presence of the bandicoot and in the absence of the Mus decumanus. These two peculiarities are probably associated with one another. The bandicoot occupies the same position among the rats of Madras that Mus decumanus occupies among the rats of Bombay and Calcutta, and since the bandicoot is much more powerful even than Mus decumanus, there is no place for this latter rat in Madras unless it can change its habits entirely. A consideration of the rodents of Rangoon lends support to this view. In Rangoon Mus decumanus is to be found, but it is much less common than in Bombay or Calcutta; this may be due to the presence of the small bandicoots (Gunomys varius) which are, like Mus decumanus, essentially outdoor rats, and must compete with this latter species. Since the Rangoon bandicoot is much smaller than the Madras one, the grey rat can exist, though it does not flourish as in Bombay and Calcutta.

In the last report of the Plague Commission it was shown that Mus decumanus was the species which in Bombay had preponderating influence in plague dissemination. Certain conclusions may be quoted from the report (Journal of Hygiene, Vol. 7, No. 6, page 761).

"With regard to the epizootic amongst the rats the following conclusions may be formulated :—

(1) Mus decumanus and Mus rattus are equally susceptible to plague.
(2) The incidence of plague is twice as great on the decumanus population as on the rattus population.
(3) Mus decumanus is the species which is chiefly responsible for the diffusion of plague amongst the rats throughout Bombay City.
(4) The decumanus epizootic precedes the rattus epizootic by a mean interval of about 10 days.
(5) The rattus epizootic is directly attributable to the decumanus epizootic.
(6) Plague persists in the rats in Bombay City during the off season. This persistence is due chiefly to Mus decumanus."

The conflicting nature of the first and second statements are reconciled and explained by the fact, that Mus decumanus, on an average, harbours twice as many fleas as Mus rattus.

It seems therefore that Mus decumanus is an important factor in the sanitation of a port. After reading the conclusions quoted above, anyone must be struck with the coincidence that Madras, the one large port in India which does not harbour Mus decumanus is the one port which has never been seriously infected with

* This statement rests on the following evidence. During a brief visit to Madras City, I examined over 1,000 rats at the Municipal rat collecting station. These had been collected from many parts of the city. Not a single specimen of Mus decumanus was found among them. This evidence is not in itself conclusive, but I was assured by the official in charge of the collecting operations that the rats seen were representative of those usually obtained; moreover, I noticed that certain uncommon rats such as Mus mettada, Vandaleuria oleracea and Gerbillus cuvieri were known by sight, if not by name, at the collecting station. In reply to my enquiries about large grey short-tailed rats, I was informed that some weeks ago a rat which was probably Mus decumanus was sent to the Madras Museum for identification. I obtained permission to examine this particular specimen. It was plainly a large Gunomys bengalensis (the skulls of Gunomys bengalensis and Mus decumanus can be distinguished at a glance).

plague.† That Madras is not wholly protected by its climate is shown by the fact that there has been at least one outbreak of plague, temporary but severe, on the outskirts of the City.

On the other hand it must be remembered that plague persists to a grievous extent among certain provinces of India into which Mus decumanus seldom or never penetrates.

The insanitary effect of decumanus as a port rat can be seen from another point of view. In a port where this rat is firmly established, there must be much more interchange between ship and shore rats than in a port like Madras where the large bandicoot alone is the common outdoor rat, for the bandicoots probably never enter ships, whereas Mus decumanus is perhaps the commonest of all sea-going rats. It has not yet been thoroughly ascertained to what extent the different species of rats infest ships plying in tropical seas. Judging from very scanty observations and inquiries, it appears that any one ship harbours only one species at a time, sometimes Mus rattus, more often decumanus. A thorough investigation of this subject would be interesting and important.

The Inland Distribution of Mus Decumanus.

It appears that, notwithstanding many statements to the contrary, Mus decumanus does not occur in India except in sea ports. This statement may be proved, in the future, to be erroneous, but all the evidence of this inquiry is in favour of the view that the grey rat has not established itself in any part of the interior of the peninsula. Certain writers relate how this rat passes up the great rivers by means of country boats to establish itself in river-side towns, and it has even been stated that it is fast replacing the indigenous rat in India. Allahabad and Cawnpore are situated on the banks of the Ganges, navigable for country boats; in both of these cities many thousands of rats were caught, but not one Mus decumanus was among them. It is impossible that they could have been overlooked, for in both places the officers in charge of the operations paid great attention to the question of the species caught, and Mus decumanus can be easily distinguished from Mus rattus.

Other Observations bearing on the Question of Plague Dissemination.

It has been sufficiently shown, that the species Mus rattus is the common house rat throughout the whole peninsula of India, that it occurs intimately associated with man in every place (with the single exception of Quetta) in which it has been looked for. The fact of its absence from Quetta is doubtful and requires confirmation.‡ If it could be shown that this species is rare in, or absent from, Quetta, the cause of its absence should be carefully sought for as it might have a direct bearing on plague prevention. It has been shown that, in any town, rats of this species show individual differences from one another, and that in certain places they show slight racial differences; so that, although it is often impossible to say whether a particular rat was native to Tellicherry or Amritsar, it would be easy to identify a group of 50 rats from either place. In certain cases, however, individuals could be identified. For example, single rats from Cashmere, Amritsar and Khatmandu could be almost always identified at a glance. In spite of this, the fact remains that any of a small collection of house rats from Adelaide in Australia can be "matched" exactly, by searching among large numbers of the rats of Calcutta, Bombay, Cawnpore or of many other large towns on the plains of India. In colour they can be matched as closely as two threads in the same skein of coloured silk. In proportions of body and skull the similarities are not less than those indicated by this comparison. Therefore it seems that there is no reason why a rat should not wander freely in or out of the country, and intermingle with the rats of places far removed from its own birth-place, without being recognised as an interloper. However, all the evidence that can be obtained shows that rats do not wander freely, that they rarely move from village to village of an Indian rural district, and that they even confine themselves to particular houses or groups of houses, and are much given to breeding within the family circle.

To obtain sure evidence about such a question is a matter of some difficulty. It might be obtained experimentally by means of marked rats. Fortunately cases have occurred in which nature has herself provided the mark. Captain G. I. Davys, I.M.S., has contributed a good example from the Amritsar district, and pointed out its significance. Among a mixed collection of Mus rattus from any large Indian town there is often a small number of white-bellied ones. Among the large number of rats which we received from the Punjaub was a small sprinkling of such forms, and it was definitely ascertained by the sender that out of 69 villages in which rats had been collected only three provided these white-bellied rats and that they made up about ten per cent. of the total rats of those villages. Whether we regard the white-bellied rats as a separate race or not, there is clearly not much intercourse between the rodents of those villages.

Two other cases have been described which show conclusively that a group of rats may identify itself

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† It is probable that Colombo has the same kind of rat population as Madras. Mr. F. E. West, F.Z.S., a gentleman residing in Colombo, has inaugurated rat destruction in that port. During a recent visit to Calcutta, he informed me that large bandicoots and Mus rattus were commonly received at Colombo, but was unable to give definite information as to the presence or absence of Mus decumanus. Since Colombo is, like Madras, a plague-free port it is important that this question should be settled. If it is found that both bandicoots and Mus decumanus infest the drains of Colombo, the idea of the sanitary effect of the former is ill founded; if on the other hand it can be shown that Mus decumanus is unable to establish itself in Colombo, the probability of the truth of this idea becomes increased.

‡ Enquiries about rats were made by Mr. W. Cummings, the Honorary Curator of the Quetta Museum. He informed us that so far as he could ascertain there were no house rats in Quetta. As this statement was accompanied by a liberal presentation of various species of field rats—over 50 specimens in all—it is worthy of every consideration, for field rats are more difficult to obtain than house rats.

with certain adjoining houses. The first of these is the case in which eleven black mole-rats were caught in two adjoining houses in Rangoon during three nights, and no other kind of rat was caught at the time in those houses, although black mole-rats are very rare indeed. This shows that a "family group" may establish itself within very narrow limits, keeping without those limits all others who are not of the group. A precisely similar case was recorded from Naini Tal where the house rats found on part of Ayapata hill could always be distinguished from those which dwelt at either end of the lake although the three places were separated by less than a mile. It may be objected that these examples do not constitute fair evidence in favour of the view that the rats of one species in a town do not freely intermingle, because in these cases the rats have been marked off by their peculiarities from the majority, and held themselves aloof.

While watching large numbers of rats brought in by townsfolk, the observer is compelled to recognise that the rats of any one species are split up into a great number of "family groups" each with its own limited domain. If, for example, at a collecting station, rats of the long tailed kind are superficially examined and set aside, the accumulation which consists perhaps of some hundreds of individuals has a truly heterogeneous appearance, some few of its constituents are black or nearly so, a few are pure white below, others are white below with a grey breast stripe. Among them, there is much variation in size. The length of one may be 150 mm., the length of another 200 mm., both being obviously adult, tail length will vary from 105 per cent. to 135 per cent. of length. In respect to length or tail length, the rats can be laid out side by side in an unbroken series; the mediocre in both respects being in the majority. In respect to colour it is much more difficult to arrange them in an unbroken series. The collection will perhaps contain one or two pure black rats and four or five others of a blackish tone which show a variable mixture of brown hairs; but one cannot find, when dealing with hundreds, every shade between a black rat and a light brown one. Similarly one cannot arrange a satisfactory series between the white ventral type and the common brown ventral type, although some of the white ventral type have coloured breast strips of variable breadth, and some of the brown ventral type are very light in colour.

The collection is truly heterogeneous in appearance, although, in a broad sense, it consists of animals of one species. The individuals composing it have been brought in batches of 2 or 3 together, by the townsfolk. It is most noticeable that as a rule the individuals of any one batch very closely resembled one another. Thus the melanotic and semimelanotic rats would probably all be brought in by one man. Another man would bring unusually large rats, a third would bring 4 or 5 white-bellied rats with relatively short tails, some with breast stripes, others without. The members of the separate batches often showed a likeness to one another. This can only be explained by the fact that the members of each batch were usually taken together from a single house, the likeness being a true "family likeness." By the word family is meant a small localized group whose members are given to inbreeding. These observations point to a conclusion that the rats of one species in a town are divided into a number of groups which hold little intercourse with one another.

Experimental evidence of a more certain nature could be obtained by successively capturing, marking, releasing and after an interval recapturing a large number of rats. It might be predicted that the recapture would take place in most cases in the same house that the capture and marking was effected. Such experiments could probably be carried out without much difficulty. The rats should be caught in a trap, anæsthetized lightly by placing the traps in a closed box containing chloroform, and removed from the trap while unconscious. They might be marked by branding the tail, a system of one or more linear brands, on either of the 4 aspects of the tail, at measured distances from its root could be easily devised. Recovery from chloroform in rats takes place with certainty, and often with most disconcerting quickness. The accidental scars which are present on so many rat tails might lead to some confusion, but a system of marking by metal rings and number plates would probably prove unsatisfactory. To recapture the rats it would be probably necessary to use spring jaw traps of which there are many effective patterns. Such experiments would give direct evidence of the movements of rats in a town or village which would be of value in consideration of the mode of plague dissemination.

ABSTRACT OF PAPER ON

CATS AS PLAGUE PREVENTERS.

By Lieut.-Colonel A. BUCHANAN, I.M.S.,

Civil Surgeon, Amraoti District.

The meeting of this Congress affords a good opportunity of revising our position as regards plague prevention measures. The policy of "A little bit of everything and nothing in particular" is not good. We ought to be able to decide what measure is likely in the long run to give the best results and to devote special attention to that. Nothing new in suggesting the employment of cats for killing rats: that cats kill rats was the first

sentence most of us learned at school, but two Commissions have investigated various aspects of plague and did not consider how far the employment of the cat would fit in with the varied conditions which we find in this country, although both agreed that the rat is the cause of plague epidemics.

THREE ESSENTIAL ELEMENTS IN AN IDEAL MEASURE.

An ideal measure must be (1) *Effective*, (2) *Available* and (3) *Acceptable* to the great majority of people. Let us apply these three tests to the measures which are at present practised. All admit the value of evacuation, but the question is largely whether we can substitute any other measure for evacuation. We may dismiss disinfection, segregation, isolation, surveillance and cordons as being neither effective nor acceptable. The rebuilding of houses will take many years and will be a very slow process if adopted. The two measures that I propose to consider specially are inoculation and the keeping of cats.

INOCULATION.

Is inoculation *efficient*? The first Plague Commission expressed the opinion (page 262) that "inoculation sensibly diminishes the incidence of plague but the protection which is afforded is not absolute." The crucial experiment at Undhera in Baroda State shows that while inoculation is markedly protective, it is not completely protective. Of 27 inoculated 8 took plague and three died. We cannot therefore with confidence advise a person who has been inoculated to remain in his house after rats have died from plague. There are many who will not take the trouble to adopt any measure, but the majority of those who are willing to take precautions say that they prefer to evacuate when rats die, and ask why should we undergo the trouble of inoculation if we must leave our houses?

(2) Is it *available*? Let us suppose that the people generally accept inoculation would it be possible first to manufacture all the anti-plague prophylactic that would be required? and second would it be possible to get a sufficient staff of inoculators to inoculate the whole population in the affected areas every year when plague occurs. Possibly it would but the cost would be enormous. How many laboratories would be required?

(3) Is inoculation *acceptable*? The first Plague Commission gave their opinion that "the utility of inoculation as a practical measure depends above all things upon the extent to which the people are willing to submit to the operation. The attitude of the people generally has been the reverse of encouraging." Has anything since occurred to indicate that the attitude of the people is *much* more favourable to inoculation? Is there not still very great reluctance?

(Reference to letter from the United Provinces Government to the Government of India, 3rd December 1908 (see *Pioneer* of 6th January 1909):—"In Jaunpur the people readily consented to evacuation and co-operated in rat destruction. Inoculation was at first absolutely refused, and the people displayed bitter hostility to the measure. Later on, however, 200 were inoculated," and in Azamgarh "here also inoculation was only effected after considerable difficulty and by the personal efforts of the Collector.")

I can foresee that my line of argument is liable to be misunderstood, so let me repeat that the question which I am discussing is what is to be the *ultimate* measure and not what measures we are to practise for the present. As a temporary expedient I think inoculation is good. I have been inoculated twice myself; during the past year I inoculated 3,659 persons and my assistants did about 3,000 more; the rumours that inoculation is followed by injurious effects are absolutely unfounded. I could give many instances which would convince most people of the great value of inoculation, but there is a vast difference between a measure which may be good as a temporary expedient and one that can be recommended as an ultimate and final measure. The first Plague Commission expressed the opinion that "Haffkine's work on anti-plague inoculation constitutes a great achievement in practical medicine" and with this opinion I entirely agree, but, while giving Professor Haffkine all due credit for his great achievement, and, while regretting that the greatness of this achievement was temporarily put in the background owing to the unfortunate accident at Mulkowal, and, while hoping that this Congress will see their way to express their appreciation of the action which has been taken by the Home Government in re-employing Professor Haffkine in India, I think it cannot be said that inoculation so far fulfils the three conditions Efficient, Available and Acceptable as to make it likely that it can be accepted as our *ultimate* policy.

INOCULATION AND VACCINATION.

We know that the opposition to vaccination was in the early days very great and that now it is accepted with great willingness and many think that the opposition to inoculation will disappear also. There is a great difference between the two. In the first place in vaccination we employ what is evidently a living germ and confer a lasting immunity; while in inoculation we use a dead culture and the immunity is only temporary. If a person is not vaccinated there is practically no escape from small-pox in India, but if not inoculated there is an easy way of escape from plague by evacuation. Further, the danger from small-pox is constant, while the danger from plague is only for the short period while rats are dying from plague. There are many who will do nothing: those who are willing and anxious to do something say we have a complete protection by evacuation; we will adopt evacuation until you can give us something better, and evacuation is becoming popular by leaps and bounds.

THE THREE TESTS APPLIED TO CATS.

(1) Is the cat effective? The opinion of the people expressed in the query How can a rat remain in a house with a cat?; evidence from what I have seen; the evidence of Professor Koch who found the cat successful in keeping rats away from German ships; and lastly the evidence of Kitisato who after making experiments with some cats that were sent from India has written :—

"The cats you sent me were found to be the most

exquisite kind of rat catchers; they are all healthy and doing their work vigorously; I am therefore thinking of multiplying this good race in Japan in order to distribute them among the infested regions" and again he wrote "the Indian cats are better than those which we have in Japan in respect to their rat killing nature."

(2) Are cats available? Information not complete but enquiries made from people from most parts of India give grounds for thinking that cats are fairly numerous. A Cat Census in Amraoti District showed 33,000 cats as the approximate number (population 800,000); there is a difficulty in taking an exact census owing to the fact that so many cats are "bewaris" that is wandering from house to house. In some places there are more than enough; what is required is more even distribution.

(3) Are they acceptable? A question full of complications, 4 main religions; Jains, Parsees, Mahomedans and Hindus. The Hindus divided into two main groups according to religion, worshippers of Vishnu (the Preserver) and Shiva (the Destroyer). The Shivaites are mostly willing to keep cats; the Vaishnavas are doubtful. Four divisions according to caste. Most Brahmins, all Chattriyas, nearly all Sudras, are willing to keep cats. The Vaishyas, the least willing but many are undecided. The Jains, Marwaris and Bhowani Dhers are important groups because it will be seen that plague frequently starts from their houses. The Parsee is the keenest rat-destroyer so the fact that he does not keep a cat (as a rule) is not a matter of importance.

Orthodoxy or a deviation from orthodoxy have also to be considered; also the influence of poverty, for the cost may prevent some from keeping a cat, whereas the wealthy will often keep far more than are actually necessary. Belief in the principle of "Kaya Rakhe Dharm" (Self-preservation is the first law of nature) also exerts a marked influence.

The cat is effective: it is available in some places at present and as cats breed twice a year the numbers would increase rapidly under proper protection. Every house with a female cat would be a Laboratory for manufacturing something that would be good for preventing plague; contrast with the possibilities of extending laboratories for making anti-plague prophylactic. For two years and a half I have been advising the people to keep cats, and there is no other measure which the people will so willingly accept. The only difficulty that I experienced excepting among a very small number is the want of a depôt from which cats could be supplied.

OTHER INFLUENCES.

Rat destruction campaigns have frequently failed because Hindus were expected to take a direct part in the destruction of rats. Most Hindus worship the god Ganpati, and, as rats are the means of locomotion of this god, Hindus have a special antipathy against killing rats: but curiously enough most of those who object to killing rats with their own hand will have no objection to keeping cats. There are many other curious customs regarding cats and rats (Wadders: Pardhis: Koshtis).

PENALTIES FOR KILLING CATS.

Another point in favor of the cat is the fact that a severe penalty is imposed on the Hindu who kills a cat. He must have a golden cat made which he will either wear, hung round his neck, or present at a shrine in Benares. Up-country he has to make a pilgrimage to Hurdwar (compare with the custom in Egypt and Rome where a man who killed a cat even accidentally was put to death. A Welsh King who died about 938 imposed a penalty for killing a cat.)

A remarkable fact: the cat is the only animal that is sacred or specially protected among both Hindus and Mahomedans, and they form the bulk of the population.

EVIDENCE THAT THE CAT WILL PREVENT PLAGUE.

A large amount of evidence has been collected in 3 epidemics: it might be put under the following heads:—

(1) General grounds: Imagine hearing for the first time that rats are the cause of plague; that the great mass of the people are in favour of keeping cats; that it is almost a religious duty with Mahomedans to keep a cat; that the killing of a cat among Hindus is considered a very heinous offence; would you not say that it seems a good thing to recommend the keeping of cats?

(2) Arguments from villages: (3) from groups of houses or mohullas and (4) from houses with cats.

(5) From Castes: The Bhowani Dhers don't keep cats as a rule though a few may keep male cats: the birth of kittens or the death of a cat in a Bhowani's house is a serious matter for him and he is put temporarily out of caste. Some Bhowanis live in wattle huts and seldom suffer from plague for the rat does not seem to choose this kind of hut: those who live in mud-walled houses suffer specially from plague for the mud wall is the favourite home of the black rat. The Marwaris are largely dealers in grain and they do not keep cats as a rule. They form about 1 per cent. of the population in this district, but in the present plague season plague has started in a Marwari's house in most of the towns and villages in which plague has occurred. The history of plague this year in Amraoti district might be summarised:—Marwaris: granaries: no cats: rats: plague.

In connexion with this point see page 122, First Plague Commission Report (1901): evidence of Mr. Giles, Commissioner of Sind:—"Then there is something in the retail grain shops, the nature of which is uncertain. I do not for a moment say that the grain gives the infection, but the Baniah's shops where the grain is sold and the flour mills are dangerous places."

And on same page: evidence of Professor Muller:—"Mandvi (in Bombay) being the centre of the grain godowns (stores) there are perhaps more rats there than anywhere else."

DANGEROUS TRADES.

Gunpowder: Kerosene oil: but worse than these are the grain stores where no cats are kept. If Marwaris will not keep cats then the advisability of making them keep their grain outside a town might be considered.

VAGARIES OF PLAGUE.

The *Pioneer* recently gave an interesting review of the course of plague: in 1904 a million deaths: in 1905 a million deaths: in 1906 a drop to a third and remarked that "Medical experts could give no satisfactory explanation, but it was hoped that plague had expended its virulence and that the worst periods had been tided over. Then came the appalling total of 1,316,000 in 1907." This was followed by what was called an "inexplicable lull when the deaths fell to one-eighth. Are these severe outbursts with succeeding lulls really inexplicable? The course of plague might be compared to a balance with cats on one side and rats on the other; the scale with the cats goes lower and lower and finally tilts over emptying out all the rats when an epizootic comes; this scale again begins to fill but probably not so quickly as before for some people will have begun to keep cats; the rapidity of filling is influenced by the presence or absence of granaries and also by the number of cats or by rat destruction campaigns; when the cats are sufficient the rats will not increase. All over India this balance is swinging to one side or the other: in some places a vigorous rat destruction campaign may make a temporary alteration. The movement of this balance is at present concealed from view, but it might be brought to light; and when it is brought to light we shall begin to know more about what now we call the vagaries of plague. By taking a cat census in a few selected areas we can tell what is happening now and what is likely to happen in the future. If the scale with the rats is sinking, then the probability is that plague will recur; if the scale with the cats is going down, then we shall have less or no plague. Kitisato has taken up the study of plague from this point of view and he finds in Tokio City 4·08%; in Tokio district 8%; in Yokohama City 12%; in the district of Kanagawa 32%; and in Yamanashi where cats are kept to protect the silk the percentage is as high as 49. *The taking of a cat census in selected areas must it seems to me form the basis of any study in plague prevention in this country.*

CONCLUSION.

What I wish to lay stress on is the necessity of choosing what is to be the *ultimate* method of preventing plague in India. If it is to be by inoculation then where is all the material and staff to come from? If it is to be by rat destruction are we medical men to spend the rest of our service in India in learning and practising the art of rat catching? or are we to take advantage of the facts that cats are already numerous in India although not sufficient, that the excellence of the Indian cat has been placed beyond all doubt, that with the Mahomedans it is a religious duty to keep a cat, that among the Hindus the killing of a cat is considered a great sin, and of the very important fact that of all the measures proposed there is none which the *great* majority of the people will accept so readily.

I would then suggest—

(1) that attention should be specially directed towards the part played by the cat in preventing plague;

(2) that a cat census be taken in selected areas;

(3) that arrangements be made for the more equal distribution of cats; and

(4) that the protection of cats be generally encouraged.

DISCUSSION.

Dr. Sukhia inquired how the fact of plague occurring in houses that harbour cats is to be explained.

Dr. Kulkarni said:—As regards the desirability of the destruction of rats, there can be no doubt. It is only the means with which they are to be destroyed that is to be discussed. The cat is the most natural destroyer of rats. Col. Buchanan told us that he learnt this fact from a village where there were no rats and where there were plenty of milk-cattle which could allow the cats to grow. There is a point in selection of milk cattle. There are two kinds,—the cow and the she-buffalo. The cow is well known in India to be the most sacred animal in the world. The secretions and excreta of cows are most sacred, while those of she buffaloes are condemned. People in our side have got prejudices against the dung of she buffaloes. They will not cover the floor of their houses with the dung of she-buffaloes because they think that this gives good nidus for the breeding of fleas and other insects, while they will cover the ground with the dung of cows. They have got some observations that this does not breed fleas, it is purer and cleaner and healthier. I have seen some superstitious Brahmins cover the ground of their houses with cow-dung mixed with the urine of the same cows, and they said this process wards off all diseases in the house. Be it rat-flea or anything, one thing is certain from observation made in many villages and that is that before the rats begin to die the houses in the villages become infested with fleas and bugs at least for a period of a month or two. Suppose all the rats were killed, the rat-flea will disappear but the myriads of fleas and bugs are sure to feed upon the habitants of the house and are sure to produce a disease which may not be plague but worse than plague.

A day will come when you will have to think of this point more seriously. Then the condition of the floor of the house will have to be inquired into, and this popular belief of the sacredness of the cow will have to be tried and tested. I appeal to Dr. Buchanan to teach people to prefer a cow to a she-buffalo for milking purposes. Milk-cattle of course enable you to keep a cat which is a really carnivorous animal and if no animal food is allowed it, it will find it in the rat and make you free from plague.

Dr. Newell supported the views of Lieut.-Col. Buchanan, and in doing so referred to the laudable step taken by the authorities at Mandalay in establishing a cat farm.

Lieut.-Col. Buchanan, in the course of his reply, reiterated his doctrine and said that if there was no host there could be no fleas.

KALA AZAR IN MADRAS.

By Major C. DONOVAN, I.M.S.,

Second Physician, General Hospital, Madras.

In the paper I intend to read to you to-day, I shall not attempt to go over all the facts relating to this disease, most of these are well known, but shall limit myself to certain factors not generally recognised by the majority of observers investigating tropical diseases.

I shall take up the following four heads :—

I.—The nature of the parasite.

II.—The mode of transmission of the disease.

III.—The diagnosis of the disease, especially by the examination of the finger blood.

IV.—Attempts at cure, by (*a*) drugs, (*b*) by bringing on inflammation and (*c*) by change of residence.

As far as the Madras Presidency is concerned the disease is very limited in its distribution, being strictly confined to the municipal boundaries of the Corporation of Madras and particularly so to the old native city, previously called Blacktown but now more euphemistically known under the appellation of Georgetown, in honour of the recent visit of His Highness the Prince of Wales.

The cases admitted from the district have, on closer investigation of their history, invariably been found to have contracted the malady within the city precincts. Kala Azar has evidently existed in Madras for a long time, it has been well-known as "Blacktown Fever" for the last 30 years at least; I remember on my first arrival in Madras now nearly 18 years ago, Col. King, the late able Sanitary Commissioner of our Presidency, speaking to me of its existence in Blacktown, and comparing it in its malignity to the dread malarial fever of Cuddapah. He considered the disease, as well as I recollect, to be a form *sui generis* and not the ordinary malaria. Up to the end of last year, I have had 379 admissions for this disease in my wards, that is, since I discovered the parasite in the spleen blood of a boy named Doraisamy, on the 16th June 1903. In addition to the above number, I have seen and examined, roughly speaking, about 150 in the wards of the other three physicians attached to the General Hospital.

This gives a total of about 530 cases that have come under my observation. Of my own admissions, there occurred 30 in the half-year 1903, 110 in 1904, 140 in 1905 (I was absent on leave in 1906), 40 in the half-year 1907 and 59 last year. The admissions for this disease do not appear to be so frequent or of so virulent a nature as previously. What the old physicians would call a "change of type" has taken place. I throw out this suggestion very guardedly, as I have not had the same number of severe cases as in previous years.

I.—Nature of the Parasite.—A considerable amount of controversy has taken place as to what position the parasite of Kala Azar should take in the order of Protozoa, but since Rogers'[1] discovery of the growth of Leishmania in citrate of sodium solution, and more so by its pullulation in the nutrient fluids of Novy[2] and more recently, of Nicolle,[3] there can be but little doubt that the organism is to be referred to the class Mastigophora or that of the flagellates, and more especially to the genus Herpetomonas. Not so much to the type species H. muscæ-domesticæ of Burnett, as to the smaller species found in the plant feeding bugs or Rhynchotes, especially to H. lygæi (Patton), found in the gut of the bug, Lygæus militaris, commonly occurring on the Milk weed, Calotropis gigantea and H. inhospes. sps. nov. found in the intestinal contents of another bug L. hospes, frequenting the pods of the Red Silk Cotton tree, Bombax malabaricum. In these Rhynchotes, stages almost identical with those of Leishmania Donovani are present in all gradations from the inert looking cockle-shaped mass, as found in man, to the long flagellated forms in citrate of sodium solution. The appearances are surprisingly alike. Patton has gone into this question in a paper which has recently appeared in the Archiv für Portistenkunde.[4] To the other herpetomonads the resemblance is not so close. I have compared them to flagellates of this genus in several flies, Sarcophaga, Calliphora, etc. The coloured plate accompanying this paper, carefully drawn by means of Abbe's camera lucida, will show at a glance the close morphological similarity I speak of.

Now, as far as I am acquainted with the parasitic flagellates, no herpetomonads are found in the gut of biting insects; flies, for instance, of the genera Hæmatopota, Tabanus and Stomoxys; Culicids like Anopheles; and bugs of predatory nature like Conorrhinus [illegible]ierris; here we have to do with the more advanced and highly organised genus Crithidia, forms approaching the trypanosomes in their complexity of structure.

There appears to be still a considerable amount of confusion, one may say ignorance of the three parasitic genera, Herpetomonas, Crithidia and Trypanosoma; all forms not in possession of an undulatory membrane and a posteriorly placed blepharoplast are loosely called "herpetomonas" forms or "wild trypanosomes" (sic). As I have had under observation during the last 18 months a number of these three genera, I may be pardoned for my presumption, in setting this question on a sounder basis.

[1] Rogers. Lancet, 23rd July 1904, p. 215.

[2] Novy and MacNeal. On the cultivation of Trypanosoma Brucei, Journal of Infectious Diseases, Vol. I, 1904, p. 1, and On the Trypanosomes of Birds. *Id.* Vol. 2, 1905, p. 256.

[3] Nicolle. Culture des corps de Leishman isolés de la rate dans trois cas d'anémie splénique infantile. Bulletin de la Société de Pathologie Exotique. Tome I, 1908, p. 121, and Sur trois cas d'infection splénique infantile a corps de Leishman observés en Tunisie. Archives de l'Institut Pasteur de Tunis. Fascicule I, Fevrier 1908.

[4] Patton. Herpetomonas lygæi. Archiv für Protistenkunde. Band XIII, 1908, p. 1.

With the help of a coloured plate carefully drawn to scale, I hope I may be explicit enough to do so. The full grown form of the genus Herpetomonas is characterised by a blepharoplast placed almost at the very extreme anterior end and with no signs of an undulatory membrane. The largest forms are found in this genus, for instance, H. muscæ-domesticæ measures 70 μ to 120 μ including the flagellum. This genus occurs in the non-biting flies and plant frequenting bugs.

In Crithidia the blepharoplast is located near and anterior to the nucleus; there is also present what may be called a rudimentary undulatory membrane. The parasites of this genus are found in the gut of the biting flies in predatory and plant frequenting bugs, in mosquitoes and in ticks. In Trypanosoma we have the blepharoplast placed at the very extreme posterior end and an undulatory membrane very well developed. These forms are parasitic in the vertebrates. These distinguishing characters are usually very well pronounced, but in the gut of some of the non-biting flies, especially in Sarcophaga, all gradations are present as far as the location of the blepharoplast is concerned; for instance, this may be anterior or posterior to or near the nucleus, the undulatory membrane, however, is always absent. (*Vide* Plate I, Fig. 7.)

It is clear that Leishmania belongs to the first-named genus of these flagellates, and, as mentioned before, very similar to Herpetomonas lygæi and inhospes. The question then is, should we still retain the genus Leishmania for the parasite of Kala Azar or incorporate it in that of Herpetomonas. As more investigations are made amongst parasites of this group, other generic distinctions will be discovered thus necessitating a further splitting up of the genus Herpetomonas. Already an attempt[5] has been made to recreate a new genus, Leptomonas for Herpetomonas found in non-biting diptera of the genus Drosophila. These forms are very like Herpetomonas lygæi and inhospes and, as mentioned before, these two species are almost identical morphologically with Leishmania; consequently this genus may be merged in Leptomonas. But as Leishmania has, as far as is known at present, a peculiarly limited habitat, *i.e.*, restricted to mammals, we are compelled to retain this genus, not so much on morphological as on œcological grounds. The old genus Herpetomonas may be split into:—

Herpetomonas.—The type being the large flagellate, H. muscæ-domesticæ,* (Burnett)[6] occurring in the gut of the common house fly.

Leptomonas.—A smaller and slenderer form found in the gut of the plant-frequenting bugs of the genus Lygæus, etc. Type L. drosophilæ (Chatton and Alilaire).[7]

Leishmania.—The form occurring in mammals, the type being L. Donovani (Laveran and Mesnil).[8]

All this speaks against the previous views[9] I held as to the nature of the parasite of Kala Azar, that it was a piroplasma; further and closer study of the flagellates has convinced me of my error in the localization of the organism in the group, sporozoa.

I may be premature in abandoning the piroplasma theory, since my knowledge of the piroplasmata of cattle and dogs is not very extensive nor, as far as I understand, has the recent work on the life history of the piroplasmata added very much in elucidation of the cycle undergone by these organisms, especially that portion taking place in the tick.

The very recent discovery, by Mesnil and Brimont,[10] of a flagellate (Endotrypanum Schaudinni) in the red blood corpuscles of an Edentate (Cholœpus didactylus), brings these organisms in very close relationship to the piroplasmata.

II. *The Mode of Transmission of the Disease.*—The mode of transmission of this ailment is still doubtful; Patton[12] has, however, made a step in this direction by finding flagellate forms of Leishmania in the gut of the common bed bug (Cimex rotundatus) of Madras. These insects he fed on severe cases of Kala Azar, in which the parasites existed in large numbers in the peripheral blood stream; but he was successful in only one case, as well as I recollect. Further attempts he made last year in this direction were not successful. I have on several occasions tried to confirm Patton's find by feeding the bed bugs on Kala Azar patients but have not up to the present met with any success.

According to Patton, the patient must be *in articulo mortis*, and the parasite present in large numbers in the peripheral circulation in the wandering endothelium cells, to the extent of 100 and more in one slide, to succeed in this bug-feeding experiment.

Such suitable subjects I have had on three different occasions, but have found no change in the forms of Leishmania ingested by the Cimices even after a week and ten days. Patton has shown me the slides containing the smears of the gut contents of the bugs in which he found the development forms; in these I can confirm the presence of flagellates similar to those obtained in the citrate of sodium solution of Rogers, that is, organisms identical

[5] Chatton and Alilaire. Co-existence d'un Leptomonas (Herpetomonas) et d'un Trypanosoma chez un muscide non vulnérant Drosophila confusa, Staeger. Comptes rendus de la Société de Biologie. Tome LXIV, 1908, p. 1004.

* H. muscæ-domesticæ is not biflagellate as Prowazek[11] has attempted to make out, those with two flagella are dividing forms and such individuals are by far the most common kind met with in the gut of some Musca domestica.

[6] Bütschli. Protozoa. Bronn's Klassen und Ordnungen des Tierreichs. Band I, 1880-1889.

[11] Prowazek. Die Entwicklung von Herpetomonas, einem mit den Trypanosomen verwandten Flagellaten. Arbeiten aus dem Kaiserlichen Gesundheitsamte. Band XX, 1904, p. 440.

[7] Chatton and Alilaire. *Vide* 5 *supra*.

[8] Laveran and Mesnil. Sur un Protozoaire nouveau (Piroplasma Donovani, Lav. et Mesn.) parasite d'une fièvre de l'Inde. Comptes rendus de l'Academie des Sciences. Tome CXXXVII, 1903, p. 957.

[9] Donovan. Human Piroplasmosis. Lancet. 10th September, 1904, p. 744.

[10] Mesnil and Brimont. Sur un Hèmatozoaire nouveau (Endotrypanum, n. gen.) d'un Edenté de Guyane. Comptes rendus de la Société de Biologie. Tome LXV, 1908, p. 581.

[12] Patton. Development of the Leishman Donovan parasite in Cimex rotundatus. Scientific Memoirs by the Officers of the Medical and Sanitary Departments of the Government of India, Nos. 27 and 30, 1907.

with the flagellates belonging to the genus herpetomonas. I have examined over 200 bed bugs, procured at random, in Georgetown and the Hospital but found no flagellates of any description in their guts ; hence it may be stated, from this very limited experience, that a flagellate and particularly the genus herpetomonas, is not a natural parasite or rather commensal of the bed bug of Madras.

Other bugs or rhynchota, congeners of the domestic bug or cimex, both plant feeding and predatory, harbour flagellates of the genera herpetomonas and crithidia. The plant feeding containing the former and the predatory the latter genus. I have found them commonly present in the gut contents of members of the families, reduviidæ and pentatomidæ and Patton in lygæidæ and hydrometridæ.[13] Hence at present, Patton's view concerning the transmission of Kala Azar by bed bugs cannot be accepted in its entirety ; that is to say, the herpetomonads he found in the gut contents of Cimex rotundatus may be only the natural commensals of this insect; if so, it must be admitted that they are of very infrequent occurrence as such.

In some of the plant frequenting rhynchotes the forms of herpetomonas were almost identical in all details with Leishmania Donovani, both as found in the human body and in the flagellate stage in Rogers' citrate solution, facts I have mentioned before when discussing the nature of the parasite.

Being dissatisfied with my attempts in bringing about an infection of Cimex with Leishmania and procuring the flagellate forms, I searched for some other blood-sucking insect of local distribution and not so universally spread as the ubiquitous bed bug, and at the same time commensurate in its range with the occurrence of Kala Azar. In my search I came across an insect answering one of the two above desiderata and, although, up to the present, I have not met with any success in propagating, much less transmitting, Leishmania by its means, I consider the find may be an interesting factor in the causation of some disease not necessarily Kala Azar. The insect in question is a black and red bug (Conorrhinus rubrofasciatus, de Geer) of large dimensions, about 20 to 25 millimetres, or, roughly speaking, about an inch in length ; it comes occasionally to the light of a lamp into rooms at nights and appears to be widely spread in Madras. (Plate I, Fig. 8.)

It is popularly supposed to suck the blood of human beings and also to feed on the common bed bug; from its latter propensity it is called, according to some of my informants, the "mother of bugs," on account, I suppose, of her unmatronly habit of devouring her smaller relations. This predatory habit on bed bugs is also attributed to its European representative, Reduvius personatus,[14] so a certain amount of credence is to be placed on one of the above popular statements of its habits. Both the male and female insects I have captured contained either fresh or digested mammalian blood in their guts, whether human or not I regret I am unable at present to determine; but hope to procure the opinion of a bacteriologist at some subsequent date.

These bugs readily suck human blood when placed, confined; in either a glass-bottom box or test tube, on the body of a person; they insert their proboscis and begin to suck as if to the manner born. Both the male and female imagines suck human blood; but the nymphs are much more bloodthirsty, starting to insert their probosces immediately they are placed on a patient, while the adults take a minute and more before they settle down to a meal. In the gut of the adult insects, in nearly 90 per cent, large numbers of flagellates of the genus Crithidia are found but no Herpetomonas.

This reduviid bug has a wide distribution both in and out of India, Distant, in the Fauna of British India Series, Rhynchota, Vol. II, p. 286, gives the following habitats ;—Sylhet, Bombay, Borghat, Calcutta and Mysore. Ceylon, Andaman Islands, Burma, Toungoo and Mandalay. Outside India it is widely spread throughout the Malayan Peninsula and Archipelago ; recorded from Madagascar, West Africa and generally found in the Southern Nearctic and Northern Neotropical regions and in the Antilles.

As mentioned before this insect's habits are nocturnal; both the male and female, the former more frequently, fly into the verandah or room attracted by light. It is found all the year round and I have procured specimens from all parts of the city of Madras.

A strange and interesting coincidence is Darwin's account of a species of the same genus, found in the Pampas district in South America ; I quote from his "Voyage of the Beagle" (page 330 of the 1873 edition).

"We slept in the village of Luxan, which is a small place surrounded by gardens and forms the most southern cultivated district in the province of Mendoza, it is five leagues south of the capital. At night I experienced an attack (for it deserves no less a name) of the Benchuca, a species of Reduvius, the great black bug of the Pampas. It is most disgusting to feel soft wingless insects, about an inch long, crawling over one's body. Before sucking they are quite thin, but afterwards they become round and bloated with blood and in this state are easily crushed. One which I caught at Iquique (for they are found in Chili and Peru) was very empty. When placed on a table and, though surrounded by people, if a finger was presented the bold insect would immediately protrude its sucker, make a charge, and, if allowed, draw blood. No pain was caused by the wound. It was curious to watch its body during the act of sucking, as in less than ten minutes it changed from being as flat as a wafer to a globular form. This one feast, for which the benchuca was indebted to one of the officers, kept it fat during four whole months; but after the first fortnight it was quite ready to have another suck."

Darwin's insect belongs to the species C. infestans, Klug (renggeri, Herrich-Schäffer).[15] It is called wing-

[13] Patton. The Life Cycle of a species of Crithidia, parasitic in the intestinal tract of Gerris fossarum, Fabr. Archiv für Protistenkunde. Band XII, 1908, p. 131.

[14] Westwood. Modern Classification of Insects, Vol. II, 1840, p. 472.

[15] Distant. Rhynchota, Vol. II, 1904, p. 285. Fauna of British India.

less, so it was evidently the nymphs he was dealing with, the adults being winged. It is similarly the case with C. rubrofasciatus; adults suck but they are not so voracious as the nymphs nor do the former become globular from sucking. No ill effects apparently follow the sting of Darwin's insect but in the case of C. sanguisuga in Arizona,[16] great pain and inflammation ensue and may end in the gathering and discharge of pus. Several species of Reduvius attack man in Southern Europe and are frequently met within houses.

Nicolle[17] has last year implicated the ectoparasites of dogs at Tunis as transmitters of the disease, that is, if this Infantile Splenomegaly of his is caused by the same species of Leishmania as Kala Azar.

From the description there is no apparent morphological difference between L. Donovani and his L. infantum. His theory as to the part taken by the dog louse or flea is founded on very slender evidence; to wit, that the children who were affected played with dogs; this it must be admitted is a very much of a *post hoc* argument. On the other hand, what strengthens his opinion is that the stray dogs of Tunis are infected with Leishmania; he examined 145 of these animals and found that 3 harboured the parasite. So it is to be presumed a common transmitter for the dog and the human being is to be looked for. Or, may it not be that the dogs, presumably of the pariah class, fed on recent corpses dead of Infantile Splenomegaly? I have not had an opportunity of examining the pariah dogs of Madras, but intend to do so next April, when the dog-killing operations begin in our city.

III. *Diagnosis of the Disease.*—Clinically this disease is not always easy to diagnose, especially in the early stages, and I have on several occasions, at the first hasty look at patients on admission into my wards, mistaken tuberculosis of the lungs and chronic malaria for Kala Azar.

Again some of the initial cases with pyrexia bear a very close resemblance to typhoid fever. The symptoms of the disease are so protean that nearly all admissions for fever of long duration are suspected to be Kala Azar, for patients sent in for dysentery, diarrhœa, ascites and pneumonia may be and are wrongly diagnosed until time corrects the previous error.

In all chronic cachectics with history of fever the hand is invariably placed over the splenic area to detect an enlargement of the viscus. But it must be remembered that the spleen is not always enlarged; in about 2 per cent. there is no increase in its bulk.

Splenic puncture would clinch the diagnosis but I have abandoned this procedure on account of the risk undergone. I have had three deaths in 170 punctures and further attempts at such operations are, in my opinion, unjustifiable. It is only in patients on the point of death, *i.e.*, a few minutes before the last breath is drawn, that I attempt to puncture the spleen and then only for the growth of Leishmania in artificial media. The finding of the Kala Azar parasite in the peripheral circulation is easy if the observer knows anything of microscopical work and the blood smear is correctly made. My second and third year students after their first week of instruction in the microscope and blood examination find Leishmania with no unusual difficulty.

For the past twelve months particular attention has been paid to the examination of the peripheral blood of Kala Azar patients and, in 93·22 per cent. of all cases, both mild and severe, the parasite has been found in this situation either in the polymorphonuclears or in the mononuclears. The largest number in one slide, and that at the extreme edge only, was 281 and in two other cases over 100 were detected at the marginal end of the blood smear on a single slide.

As it is important to discover the cause of the disease with as little inconvenience and danger to the patient as possible, I may be permitted to go into some detail with reference to the procedure I adopt in obtaining positive finds in such a large percentage. The secret is the formation of the blood smear. A finger of the patient is taken, the tip washed with water and then dried with a towel, the finger is compressed below the pulp for half-a-minute so as to allow as many leucocytes as possible to exude in the drop of blood obtained by the prick of a new pin, one not used before. A needle's prick does not give enough blood and the employment of a surgical needle is barbarous. A small drop of blood, about the size of a large pin's head, is taken up by a slide near its end and a smear made of it by another slide passed slant-wise over it.

The main object is to have the smear end in a straight edge at the finish. All that is necessary is to examine, of course, after fixing and staining the film, this edge, here everything of importance in the smear is located, the leucocytes and any Leishmania that may be present in them; in ten minutes the whole of the contents of the drop of blood are ascertained. Some training is necessary to procure perfect slides of this nature. The slide with which the smear is made, should have a perfectly smooth-ground edge to obviate 'tailing' at the finished margin. It is by neglect of making smears of this kind that success does not attend the endeavours of other observers in detecting Leishmania in the peripheral blood. I do not profess to find the organism in 93·22 per cent. of the cases in a single slide every day, sometimes five slides have been examined on five different, not necessarily successive days, before meeting with success. Out of 59 admissions for Kala Azar last year, 55 gave positive results, 3 negative and one died before the peripheral blood could be examined, *i.e.*, the patient was admitted in the afternoon and died the same night before I could see him the following morning. On the average about two slides were examined on two different days to give the percentage obtained. The cases were not selected, they were all those admitted into my wards indiscriminately, some of a mild type, others again severe, in other words all those diagnosed clinically as Kala Azar. I am sure, however, I am missing the parasites in the very early cases, say those of a month's duration. In cases with high fever and those with complications like broncho-pneumonia, and,

[16] Sharp. Insects. Cambridge Natural History, Vol. VI, 1899, p. 559.

[17] Nicolle and Comte. Origine canine du Kala Azar. Bulletin de la Société de Pathologie Exotique, Tome I, 1908, p. 299.

on the other hand, such debilitated individuals suffering from dysenteroid or diarrhœic motions, the presence of Leishmania is fairly manifest, 4 or 5 occurring in a slide; then again, *in articulo mortis* large numbers may be present, up to 20 or 30 in a slide.

It is only exceptionally that over 100 are found. Out of the 59 admissions last year, in 3 cases were such large numbers found; in one, as mentioned, as many as 281. The parasite is always included in the white blood cells; in pyrexial in the cytoplasm of the polymorphonuclears and in diarrhœic cases in that of the macrophages of endothelial origin from the spleen or bone marrow. The largest number of Leishmania in one macrophage was 30; here they appear to be in a perfect condition and stain well; it is the reverse in the case of those included in the cytoplasm of the polymorphos, where they are apparently acted on by the ferments of these cells. I have never discovered the Kala Azar parasite in the cytoplasm of the lymphocytes or eosinophiles. Patton[18] states that he has found one in an eosinophile, but I am sure this must be an error as I have particularly sought for them in vain in these cells for the last 18 months, in the blood smears of well over a hundred cases from all sources, from puncture of the spleen, borings from the red bone marrow and from the peripheral circulation. I have recently adopted a new means of procuring Leishmania from the human body during life, and that is by boring into the head of the tibia or into the osteal portion of the ribs by means of a small gimlet. The patient is anæsthetised, either by ethyl chloride or chloroform, a slight incision made over the selected area, the bone exposed and a small portion of red bone marrow removed by an ordinary gimlet. Marrow from the head of the tibia is not so satisfactory but that from the ribs contains Leishmania in large numbers, closely packed in the endothelial cells of the myeloid tissue. The forms appear to be in a fresher condition, if I may be allowed to make use of a loose expression, but there is no change in the morphology of the organisms, no attempts at growth or any signs of the origin of the flagellum. I undertook this innovation to find out forms of the parasite possessing some manifestations of activity in giving rise to pyrexia and the other signs of *mal être* common to the disease, as it is hard to understand how the usual inert apparently encysted looking forms of Leishmania could give rise to active symptoms. I have mentioned in a previous contribution, the peculiarity of the leucocytes in Kala Azar. A knowledge of this fact is of considerable help in the diagnosis of the disease from malaria and typhoid fever, types of fevers having mononucleosis as a common characteristic. In advanced cases of Kala Azar leucopenia is marked, more so than in any other ailment that I am acquainted with; along with this there is a relative increase of the mononuclear type of leucocytes. The polymorphos are considerably changed as far as the appearance of their nucleus and cytoplasm is concerned. The granulations of the cell are diminished if not entirely absent; the nucleus loses its apparent polynuclear nature, becomes band or ribbon-shaped instead of possessing the normal strings connecting the different thickened nuclear masses. Another feature in the change of the nuclei of the polymorphonuclears is the presence of very small buds or beads on short thin pedicles attached to different parts of the nuclear substance. These peculiarities are not limited to cases of this disease, but are very much more evident than in any other ailment showing a mononuclear type of blood change. The presence of endothelium cells too is characteristic; some of these may be passed off as transition mononuclears. Division forms are common among these cells, the nucleus divides into two or more portions connected by a very slender nuclear string, taking on in others a marked polynuclear character. Occasionally beautiful mitotic figures are met with. The second plate attached shows better than any description the peculiarities alluded to. The red blood corpuscles are invariably much reduced in number, about an average of 2,500,000 to the cubic millimetre; the blood is consequently less viscous and blood smears can be very much more satisfactorily prepared than with the normal and more viscid blood. This is a fact worth remembering and a help in diagnosis. Owing to the paucity of the polymorphonuclear leucocytes the blood coagulates very slowly; and a drop of blood from a single pin-prick may be repeatedly pressed from the finger for nearly five minutes.

(*IV*).—*Attempts at cure, by* (*a*) *drugs*, (*b*) *by bringing on inflammation and* (*c*) *by change of residence.*—(*a*) I cannot state that the drugs I have tried have had any beneficial and lasting effect. Among some of the number, I may mention the various salts of quinine in large doses, both by mouth and intramuscular injection, *ad nauseam*; Liquor Arsenii et Hydrargyri Iodidi, with and without Vinum Antimonniale; Fuchsine and latterly Thymol dissolved in rectified spirits. At first I was under the impression that Fuchsine was giving satisfactory results but I have now changed my opinion. The amelioration was transitory. A single patient, a boy of about 14 years old, was the only exception: he was persuaded to stay in hospital for six months and took 1c.c. of a 20 per cent. solution of Fuchsine three times a day during this long period. He is now, 18 months after, in perfect health and is working in my laboratory at the hospital. The other physicians here have tried X-rays, Atoxyl and Soamin, but no marked change has resulted from such treatment.

(*b*). *By bringing on inflammation.*—I have had a cure of another patient after a very severe attack of cancrum oris and in the wards of the Fourth Physician, Capt. E. W. Browne, I.M.S., a patient is on a fair way to recovery after facial erysipelas.

(*c*). *Change of residence.*—"Change of air, especially "to a dry hot climate, appears to bring about a cure in "some of the cases. A few of my old Kala Azar patients "have returned to see me, restored to health and appa- "rently quite well. I may mention such places in our "Presidency, answering to suitable sanatoria (if I may

[18] Patton. Development of the Leishman-Donovan parasite in Cimex rotundatus. Scientific Memoirs by the Officers of the Medical and Sanitary Departments of the Government of India, No 30, 1907, p. 3, and Plate 3.

" use the expression) for Kala Azar ; to wit, Kurnool, " Cuddapah and Anantapur." I made this statement in our General Hospital Report for 1907. Since then I have sent two patients to Cuddapah, one of them returned after a month with but slight improvement and the other, after a three months' stay there, returned to his native place very much the worse for the change ; he suffered all the time he was at Cuddapah, with the most marked intermittent rises of temperature I have known in Kala Azar, the temperature ranging from normal to 105° F. and occurring twice a day. Both these patients have since died.

EXPLANATION OF PLATES.

All the figures, with the exception of No. 8, have been drawn by means of Abbe's Camera lucida and Zeiss's Apochromatic Objective 2 mm., num. apert. 1·40 and No. 12 Compensation Eye-piece. The surface of the drawing paper was 430 mm. from the prism of Abbe's apparatus, giving a magnification of 2,580 diameters. The staining was the author's modification of Jenner.

Plate I.

1. Herpetomonas muscæ domesticæ, Burnett.
2. Herpetomonas (Leptomonas) lygæi, Patton.
3. Herpetomonas (Leptomonas) inhospes, sps. nov.
4. Leishmania Donovani, Laveran and Mesnil, from citrate of sodium solution.
5. Crithidia Conorrhini, sps. nov.
6. Trypanosoma Evansi, Steel.
7. Herpetomonas (Leptomonas) sarcophagæ? Prowazek, showing the gradations in the localisation of the blepharoplast from the anterior to the very posterior end of the body of the flagellate.
8. Conorrhinus rubrofasciatus, de Geer. Male and female, natural size.

Plate II.

Cells in the peripheral blood.

9. Two polymorphonuclear leucocytes, showing the band or ribbon-shape of the nucleus and the small buds or beads on short thin pedicles. The granulations in the cytoplasm are diminished in number.
10. A polymorphonuclear leucocyte with 4 Leishmania in its cytoplasm.
11. A normal polymorphonuclear showing the strings connecting the 4 thickened nuclear masses, the granulations are much more numerous than those shown in the preceding 3 polymorphos.
12. An endothelial cell, the nucleus divided in two.
13. An endothelial cell with a stalked bead attached to its nucleus.
14. An endothelial cell the nuclear lobes connected by a very slender cord.
15. An endothelial cell showing mitotic figure.
16. An endothelial cell the nucleus having a very marked polynuclear appearance.

17 & 18. Endothelial cells with 6 and 30 Leishmania Donovani in their cytoplasm. The red cells in the proximity are red blood corpuscles.

DISCUSSION.

Major Rogers said :—As long ago as 1897 I pointed out the marked reduction in the number of the leucocytes in the blood of kala-azar patients, and have since found it to be the most constant and characteristic change in uncomplicated cases of this disease, and one which is of the greatest diagnostic and prognostic value. The loss is chiefly one of the polynuclears, which are commonly only from one-tenth to one-twentieth of the normal numbers, the death-rate being in proportion to the degree of their destruction. I have previously drawn attention to the remarkable recoveries which sometimes follow septic complications such as cancrum oris, but only when a marked increase of the total polynuclears occurs. As I also found cancrum oris in these cases to be accompanied by a general staphylococcus infection, which sometimes appears to produce a disappearance of the parasites of kala-azar from the internal organs I suggested and used a vaccine made of these organisms killed at 60 C, in accordance with Sir A. F. Wright's methods, and recorded in my work on Fevers in the Tropics that this method of treatment had in several cases appeared to be of undoubted value. During 1908 I have been able to further test this method, thanks largely to the kind permission of Lieutenant-Colonel Harris, I.M.S., to try it on cases in his wards at the Calcutta Medical College Hospital. The accompanying table (*see page* 165) includes all the uncomplicated cases so treated during the past year, being thus a consecutive series of unselected cases, which furnish the basis for the following observations.

Blood counts were made by myself before the vaccine was used, and again before subsequent doses, which were usually given at the intervals of from a week to ten days. One hundreth of an ordinary agar slop culture of a staphylococcus, originally obtained from a cancrum oris case of kala-azar, was contained in $2\frac{1}{2}$ minims of the stock vaccine (about 250,000,000 cocci) and the doses rapidly increased from $2\frac{1}{2}$ to 10 minims or more. The increases of the leucocytes noted were thus present from 7 to 10 days after the previous dose of vaccine had been subcutaneously injected, either in the upper arm or over the spleen, so that they represent more than the immediate effect of each dose. In addition to the counts of the red and the white corpuscles (which furnish data for calculating the ratio of the white to the red corpuscles), I also made a differential count in most of the cases, so that the actual increase in the total polynuclears could also be estimated as shown in the table.

Effect on the number of Leucocytes in the Blood.—The first noteworthy feature is the marked increase in the total number of the leucocytes which followed the injections in 12 of the 14 cases, although in two, namely Nos. 6 and 15, it was unfortunately only temporary in nature, the numbers subsequently declining again. Of the remaining two, in No. 1 a slight temporary total increase, without any rise in the total polynuclears, was obtained, while in No. 7 no increase followed the single small dose observed. In the great majority of the cases, then, a marked leucocyte increase was obtained and was accompanied by a rise in both the proportion of the white to the red corpuscles and in the percentage and total numbers of polynuclears, which is the desired result.

The General Effects of the Treatment.—As the patients were all natives, who could not be kept in hospital for long periods, only the immediate general effects can be recorded. Some were not long enough in hospital to allow of much permanent good being effected, while No. 3 contracted dysentery and died. The majority, however, showed distinct signs of improvement, the temperature declining to a very low intermittent form or to normal, and weight being gained. The results, as a whole, were certainly better than by any other treatment I have seen tried in these very unsatisfactory cases. The patients were all in an advanced stage of the disease, so that earlier and more persistent trials of this treatment seem to be indicated, especially as it can be used in addition to any drugs, which may be considered of value.

Capt. Foster said that no satisfactory method for diagnosing the affection had hitherto been demonstrated. He had failed to find the parasites in peripheral blood in 1000 blood films examined by him, and it was curious that the results at Madras and Murshidabad had so markedly differed.

Mr. Ramchandariar referred to his observations at Madras, Mysore, etc. He criticised the attitude of specialist observers whose sole attention was devoted to but one single subject to the total exclusion of all others : in fact their imagination ran riot and they were simply mad after one thing and one alone, apparently oblivious of the fact that other things and subjects existed in nature, and that theirs was but an insignificant fragment of the whole.


Plate. I.
1.
2.
3.
4.
5
6.
7.
♂
♀
8
10
20
30
40
50 μ

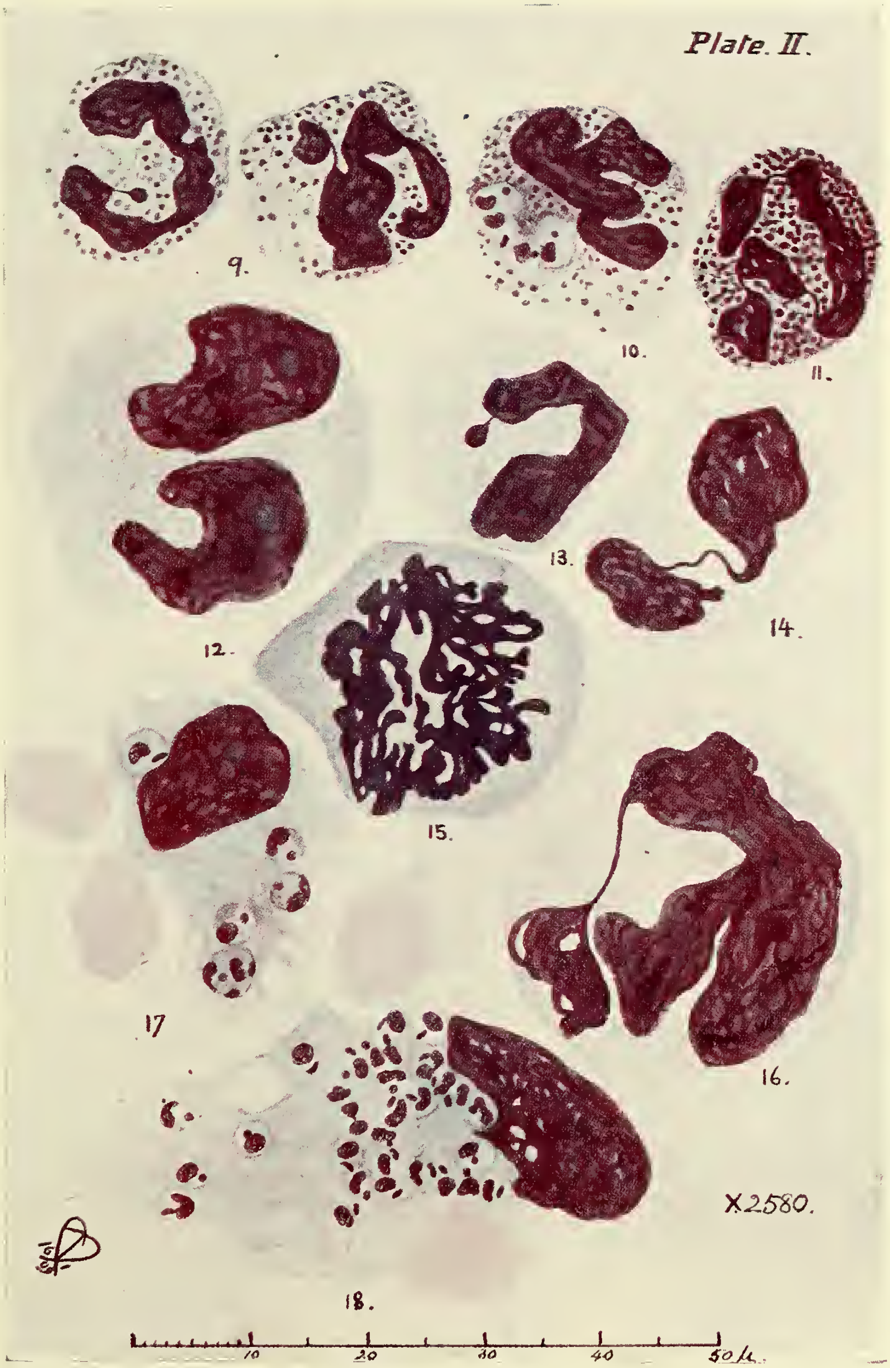


Plate. II.
9.
10.
11.
12.
13.
14.
15.
16.
17
18.
X 2580.
10
20
30
40
50 μ.

No.	Race.	Sex.	Age.	Date of Vaccine.	Dose of Vaccine.	Date of Blood Exam.	Red Corpuscles.	White Corpuscles.	Ratio red to white.	Total Polynuclears.	Percentage Polynuclears.	
1	H.	M.	21	11-3	5 Min.	11-3	3,600,000	2,875	1-1,254	1,874	65·2	Fever on.
...	...	...	...	20-3	10 „	20-3	3,880,000	3,500	1-1,109	1,643	47	
...	...	...	...	...	...	25-3	......	3,125	...	1,663	53·6	Fever much lower. Improved.
2	Nt. Ch.	M.	18	23-2	5 Min.	22-2	2,465,000	625	1-3,944	369	59	
...	...	...	...	5-3	7½ „	4-3	4,420,000	3,125	1-1,414	2,031	65	
...	...	...	...	14-3	7½ „	14-3	3,220,000	3,625	1-1,326	1,286	49	Very much improved. Temperature normal.
3	H.	F.	12	5-3	5 „	4-3	3,430,000	2,125	1-1,614	1,126	53	
...	...	...	...	15-3	5 „	15-3	2,760,000	6,375	1- 440	4,692	73·6	Much improved. Temperature normal.
...	...	...	...	...	...	...	3,190,000	6,250	1 510	4,700	75·2	Subsequently died of dysentery.
4	H.	M.	30	10-3	5 Min.	7-3	4,200,000	2,875	1-1,460	2,085	73·2	
...	..	...	...	...	...	19-3	4,260,000	12,000	1- 355	7,488	82·4	Much improved. No fever.
5	E.	F.	17	2-4	5 Min.	1-4	3,880,000	2,875	1-1,348	1,035	36	
...	...	...	...	10-4	7½ „	10-4	2,820,000	4,000	1- 705	2,080	52	Much improved. Temperature normal.
6	E.	F.	45	24-3	5 „	23-3	2,770,000	1,500	1-1,847	1,284	85·6	
...	...	...	...	31-3	7½ „	31-3	3,490,000	3,375	1-1,016	2,916	86·4	
...	...	...	...	7-4	7½ „	7-4	2,930,000	1,375	1-2,131	976	71	No improvement, died of Pneumonia later.
7	M.	M.	12	27-5	2½ „	27-5	2,105,000	2,125	1- 982	...	...	
...	...	...	...	5-6	5 „	5-6	2,505,000	1,375	1-1,322	...	...	No improvement, lost weight.
8	E	F.	30	28-4	5 „	15-4	2,500,000	1,500	1-1,667	870	58	
...	...	...	...	8-5	7½ „	8-5	2,860,000	2,750	1-1,040	1,432	63	
...	...	...	...	16-5	10 „	16-5	2,815,000	1,875	1-1,301	...	...	
...	...	...	...	16-6	10 ,	16-6	2,705,000	1,250	1-2,164	...	...	No increase of Leucocytes.
...	...	...	...	2-7	15 „	2-7	2,880,000	1,625	1-1,754	...	...	Gained in weight, slight improvement.
9	Nt. Ch.	M.	17	29-4	5 „	29-4	4,130,000	2 250	1-1,613	1,192	53	
...	...	...	...	7-5	7½ „	7-5	3,150,000	3,125	1-1,008	1,651	53	No change.
10	H.	M	12	5-7	5 „	5 7	2,580,000	1,250	1-2,069	...	...	
...	...	...	...	14-7	7½ „	14-7	3,735,000	2,500	1-1,490	1,350	54	Improved. Temperature normal.
11	H.	M.	24	30-1	2½ „	22-1	3,730,000	3,375	1-1,105	796	23·6	
...	...	...	...	14-2	5 „	14-2	3,860,000	7,750	1- 498	1,116	14·4	
...	...	...	...	11-3	7½ „	11-3	3,714,000	1,250	1-2,968	237	19	
...	...	...	...	25-3	10 „	20-3	4,120,000	1,875	1-2,197	1,143	61	
...	...	...	...	4-4	10 „	4-3	4,520,000	4,000	1-1,130	2,250	57	
...	...	...	...	11-4	10 „	11-4	4,060,000	5,000	1- 812	3,000	60	Greatly improved and gained weight. No fever.
12	H.	F.	22	5-11	10 „	4-11	2,350,000	2,375	1- 984	...	...	
...	...	...	...	...	...	16-11	2,420,000	3,500	1- 691	2,296	65·6	Improved. No fever.
13	M.	M.	38	11-11	2½ Min.	11-11	2,190,000	3,000	1- 730	...	...	
...	...	...	...	23-11	5 „	23-11	2,220,000	6,000	1- 370	3,168	52·8	
...	...	...	...	30-11	7½ „	30-11	2,345,000	6,750	1- 348	...	...	Much improved, gained weight.
14	E.	M.	15	...	...	19-12	2,515,000	3,375	1- 745	...	...	
...	...	...	...	23-1	2½ Min.	23-1	2,105,000	2,000	1-1,052	...	...	Worse, vaccine commenced.
...	...	...	...	2-2	10 „	2-2	1,715,000	1,715	1-1,744	...	...	
...	...	...	...	...	...	19-2	2,900,000	5,000	1- 580	...	...	Temperature nearly normal, gaining weight.

Col. Campbell said that vaccine treatment nad been very efficacious, and that similar treatment, through the use of issues, &c., has been known to the natives of India for centuries.

Capt. Christophers said that the relation of the Leishman-Donovan parasite to *piroplasma* depended upon the real nature of *piroplasma.* If piroplasma like the malaria parasite was onc of the Sporozoa there was no very close relationship.

Both Koch and the speaker had described a number of developmental forms of piroplasma in the tick. None of these bore any resemblance to stages of the Flagellata. On the other hand there were resemblances to stages of the malaria parasite which was a Sporozoa.

Just as in the malaria parasite flagellation occurred as a sexual process, so it might do in piroplasma, and the forms recently described in Liverpool though they had flagella bore little or no resemblance to the flagellata. They were transient forms and had no blepharoplast like that of the flagellates. The flagella were also multiple and very fine. Such forms were quite compatible with piroplasma being a sporozoan. The speaker had called attention to the possibility of a sexual flagellation occurring prior to the formation of the club shaped bodies of Koch which seemed to be analogous to the Oopinite of the malarial parasite.

Major S. P. James said: "In connexion with Major Donovan's statement that he does not now regard the Leishman-Donovan parasite as a Piroplasma, it would be of interest to know his present opinion regarding the forms of the parasite which at one time he described as being present in the red blood corpuscles, but to which he does not allude in the present paper. The omission by Major Donovan of any reference to the parasites of Oriental sore is also of interest as it points to the fact that this disease does not occur in Madras. So far as I am aware no place has yet been found in India where kala-azar and Oriental sore exist side by side. It is unfortunate that more observations relating to geographical distribution have not been made in this country, since such observations are well adapted for settling many problems in connexion with the nature and pathogenic properties of parasites of this class. Sir Patrick Manson's suggestion that the parasites of Oriental sore may be the parasites of kala-azar modified by passage through some animal also still remains untested in India. Such observations on geographical distribution as we possess at present are not unfavourable to the correctness of this view and it would be a remarkable blessing to mankind if by inoculating a person with the parasites of Oriental sore we could protect him against kala-azar."

Dr. Bently-remarked that it was evident that the disease met with by Major Donovan in Madras and Capt. Foster in Bengal was the endemic form of kala-azar in which cases rarely showed such a rapid course and acute symptoms as in the epidemic form of the disease. The speaker had seen over a thousand cases of kala-azar in an acute epidemic in Assam. This number occurred in a comparatively small population on a tea-garden. Not less than three-quarters of the entire population of two large coolie lines were entirely wiped out during a period of five years.

At the height of the epidemic cases rarely lasted longer than six months after the onset of the disease which decimated whole households. Finally the epidemic ceased as suddenly as it began, and now it was difficult to discover definite cases of kala-azar in the same place in which a few years back hundreds of cases were to be found.

During the waning of the epidemic there appeared to be an extraordinary lessening in virulence, for many cases appeared to recover spontaneously—and the speaker knew of a considerable number in whom the parasite had been found by splenic puncture who were now alive and well and apparently completely recovered. At the height of the epidemic 95 per cent. mortality occurred, but later on 50 per cent. or more recovered. The reason why the disease described by Major Donovan showed a very high mortality was undoubtedly because he was dealing with hospital cases. There must be many hundreds of milder cases, the great majority of whom never went near a hospital and eventually either recovered or died after very long continued infection.

Major Donovan had referred to diagnosis. This was still a very difficult matter. In the speaker's opinion it was practically impossible to diagnose kala-azar clinically except when it was present in the epidemic form in a locality where the medical man seeing the cases had a close personal knowledge of the patients, having been familiar with them before the onset of the disease. He would refuse to give a definite opinion upon any case or cases merely presented for his casual inspection however closely they might resemble kala-azar. Some years ago he (the speaker) drew attention to the clinical resemblances between kala-azar and Malta fever. It was an interesting point that, more recently, Bassett-Smith a recognized authority upon Malta fever, had confirmed this striking resemblance after having seen and studied cases of kala-azar. This illustrated the great difficulty of diagnosis from clinical signs.

Major Donovan had referred to the dangers of splenic puncture and the possibility or certainty of finding parasites in the peripheral blood; but his own experience did not correspond with Major Donovan's.

In the first place in close on a hundred spleen punctures he had seen no bad result. A hypodermic syringe (all glass) and a fine needle had always been employed by him. As regards the difficulty of finding the parasite in peripheral blood films his experience coincided with that of Capt. Foster.

One point must be noted however—when late in 1903 after Major Donovan's discovery of the parasite in Madras, he (the speaker) had been successful in finding for the first time the presence of the parasite in cases of kala-azar in Assam—the epidemic was already on the wane. It was quite possible that the difficulty of finding parasites in the peripheral circulation of even very severe cases at this time bore some relation to this fact. The extraordinary way in which the disease disappeared when everything appeared favourable to its spread did not however support the bed-bug hypothesis as to its transmission. As regards treatment, his experience coincided with Major Donovan's—he could not say that he had seen any definite results from any form of treatment. The peculiar course of the disease often misled people, and, as many cases recovered quite apart from treatment, mistakes arose as to the value of certain remedies.

Dr. Pettigara held that kala-azar and Delhi boil were not identical, and that he was prepared to support the views of Major Leonard Rogers from his personal observations.

OBSERVATIONS ON FEVERS IN THE PHILIPPINE ISLANDS.

By Capt. EUGENE R. WHITMORE, M.D.,

Medical Corps, U. S. Army, Manila, P. I.

With increase in our knowledge of, and experience with, diseases in the tropics, comes the knowledge that there are comparatively few diseases that are limited to the tropics, and this is especially true of the fevers, so that "Diseases in the Tropics" and "Fevers in the Tropics" seem to have become more appropriate than "Tropical Diseases" and "Tropical Fevers." However, there are some fevers that at present are not known to spread outside the tropics, while some of the cosmopolitan fevers present peculiarities in the tropics that merit special consideration.

It is not my intention to discuss all of the fevers found in the Philippine Islands, as they do not differ from the same fevers as found elsewhere; but it is my desire to note a few points that have interested me during my service here.

Malarial fever is commonly met with and, so far as I know, does not differ from the same disease elsewhere. In about five thousand positive blood examinations in a little over three thousand cases of malaria, I have found the quartan parasite in only twenty-seven cases. In 1,031 consecutive cases of which I have record of the blood finding, the sub-tertian parasite was found alone 661 times; the tertian parasite was found alone 343 times; the two were found together 23 times; and the quartan parasite was found alone 4 times. Crescents were found 73 times. The quotidian parasite does not appear after my first five hundred cases. Two cases of sub-tertian infection developed hemoglobinuria and both died. One case was an American soldier and the other was a native woman.

In one company of Native Scouts examined for malarial infection, 28 men in a company of 101 had malarial parasites in their blood. All of these men were doing duty and only one admitted that he did not feel well.

Dengue fever is common and does not need any discussion.

It is known that typhoid fever is not at all uncommon among the whites as well as the natives in all parts of the Islands where it has been carefully sought for. Whether the incidence of typhoid among the natives has increased since American occupation and the stationing of American troops in various parts of the islands, I cannot answer. In a fairly large experience

with serum reactions and blood cultures, I have never obtained agglutination of either of the paratyphoids and have never obtained a paratyphoid from the blood of a fever patient here. In testing a serum for agglutination it has been my routine to use two or three strains of typhoid and both strains of paratyphoid for every test, making serum dilutions of 1-20, 1-40 and 1-100 for each organism. I was early struck by the large number of fever cases that looked like typhoid but which did not agglutinate the laboratory strains of typhoid or paratyphoid bacilli. Blood culture on some of these cases gave an organism which could not be distinguished from the typhoid bacillus and which was agglutinated by patient's serum. In one case, a patient's serum did not agglutinate the laboratory strains of typhoid, but from the blood I obtained an organism which corresponded to the typhoid bacillus in biology, morphology, and pathogenesis, and which was agglutinated by the patient's serum. After some months, cultures of the organism were agglutinated by typhoid serum very nearly as strongly as were the stock typhoid cultures.

I have also seen a number of cases of fever which differred clinically from typhoid, malaria, and dengue. During the past year I saw two cases of fever with sudden onset, an irregular fever of about two weeks' duration, with no bowel disturbance, no eruption, and no marked degree of emaciation after the fever was over. The blood serum of these patients did not agglutinate any of my stock typhoid or paratyphoid cultures but from the blood of each patient I obtained an organism which agglutinated at 1-20, but not completely at 1-40 with the corresponding serum. These two organisms were pathogenic, and differed in morthology and some cultural characteristics from the typhoid bacillus. Unfortunately my illness at that time prevented by examining the organisms further and both organisms had died out when I returned to the laboratory.

From this it is evident that I am of the opinion that we have some cases of fever here which are due to infection with members of the abdominal group other than the typhoid bacillus, and that there are strains of the typhoid bacillus which are distinguished only by the agglutination test; further, it is probable that the failure of the agglutination test in some undoubted cases of typhoid fever, may in part be accounted for by our not having the particular strain which is causing the disease. If such should prove to be the case we would have to broaden the term "typhoid fever" or create a number of "para typhoid fevers." I am now collecting all organisms that I can from cases of typhoid-like infection in these Islands and comparing them to see whether I can find any distinct and constant differences between them.

One fever which I saw, especially at Camp Stotsenburg, has interested me greatly, and when I read "Seven-day Fever" in Rogers' "Fever in the Tropics," I was struck by the similarity between the fever he described and the one I have seen. In a report (based on two years' experience at that station) to the Chief Surgeon, Department of Luzon, on November 30, 1904, I described this fever, saying "This fever has been variously called 'simple fever,' 'simple continued fever,' and sometimes 'dengue fever,' though it is evidently entirely distinct from the latter fever. The other names have been applied simply to show that it is a different fever from the ones usually recognised."

The onset of this fever is usually sudden, with prolonged chilly feelings, but rarely a severe chill. The temperature rises suddenly or by steps for two or three days to 103°-104° or even 106°, the face is flushed from the start, in three or four days *and while the temperature is still high* a rose red macular eruption appears over the entire trunk and limbs, but the eruption may be absent or transient. There is no sweating, the skin itches intensely, the conjunctivæ are injected and there is pain in the eyes. The eruption does not appear on the palms of the hands or the soles of the feet. As the eruption comes out completely, the temperature drops, and in forty-eight to sixty hours the temperature is normal, the eruption has disappeared, and the patient feels well without pains or after-effects except that he is weak. Repeated blood examinations does not show malarial organisms, and quinine has no effect on the fever. At no time is there any more pain than would be occasioned by any acute infection when the temperature range is so high, and there are no pains afterward.

I cited the case of a man who "entered with an attack of malarial fever, sub-tertian parasites being found. He was thoroughly cinchonised, the temperature dropped to normal and the man was feeling so well that he was to return to duty. Then began a step-like rise of the temperature, reaching 104° on the fourth day after the rise began, and then a step-like fall reaching normal on the seventh day. All this time the quinine was continued and to show that the quinine had nothing to do with causing the fever, it was continued at the same dose until after the man's temperature was normal and had remained so for two days."

Blood cultures were uniformly negative in this fever and I never saw the blood from a case agglutinate typhoid or paratyphoid bacilli. I do not remember having seen the saddle-back temperature described by Rogers in "Seven-day Fever." I never saw a fatal case and I did not see a relapse or a second attack in any case. I never found any constant changes in the blood and the spleen and liver were not palpable. I have no note on the pulse. No experiments in transmitting the fever were tried.

I was familiar with Dengue Fever at that time, having seen two epidemics before going to Camp Stotsenburg.

On January 3, 1908, Dr. Christie wrote me from Camp Stotsenbug, saying: "The cases of fever which I have seen and which I consider not to be typhoid, malaria, or dengue, run a course about as follows: Disease begins sometimes with a severe chill, but more often with prolonged chilly feeling extending over a period of 12 to 24 hours, there is then a sudden rise of temperature to 102°-104°, the face is flushed; the conjunctiva congested and the patient *extremely prostrated*;

the tongue is moist and has only a moderate white coating; neither constipation nor diarrhœa are present, the bowels moving regularly and stools having a normal appearance; no pains except a headache are experienced. In about half of the nine cases that I have seen, a rash has appeared on the third or fourth day, macular in character and looking like rose spots in typhoid, but distributed over entire body and most noticeable on forearms and thighs. The temperature averages about 101° in the morning and 104°-105° in the evening for from five to seven days when it falls by lysis and reaches normal on the seventh to ninth day and remains so. Two or three days after the temperature reaches normal the patient feels perfectly well, and in none of the cases that I have seen has there been a relapse. Careful examination of the blood of these patients, on every day of their illness, was made for malarial parasites but none were ever found. In four of the cases blood cultures were made and were negative, and the same four cases failed to cause agglutination of typhoid or paratyphoid. The very acute character of the disease, the negative results from blood cultures and agglutination tests, the fact that no malarial parasites are found and the complete absence of pain, I think, establishes this as a fever different from typhoid, malaria or dengue."

Undoubtedly Dr. Christie is describing the same fever that I saw there in 1903 and 1904, and I strongly suspect that it is the same as Roger's "Seven-day Fever" in India.

I never saw a case of heatstroke or sunstroke here but have often seen fever of two or three days' duration, in which the temperature rose to 104°-105°. These cases seemed to follow direct exposure to the sun during the heat of the day and I ascribed them to the effect of the sun's rays. Possibly some of these cases correspond to "Three-day Fever" in India.

During 1904 I saw two cases of prolonged fever in which the blood agglutinated M. melitensis but was negative for typhoid and malaria. One was apparently a typical case of Malta fever with sour sweats and joint involvement, and both cases were diagnosed Malta fever, but I am inclined to doubt that diagnosis in the light of recent knowledge. Both cases recovered and were returned to duty.

I have seen small-pox, measles, mumps and whooping cough here but have not seen diphtheria, however there have recently been several cases of diphtheria in Manila and the infection seems to have spread among the natives to some extent.

From the above it is evident that I have frequently used the terms "simple fever" and "simple continued fever" to designate various fevers which I met and could not place, but I have always tried to have it understood that I used these terms merely because a diagnosis had to be made, and I desired to record my belief that these were fevers other than malaria, typhoid and dengue, thus inviting discussion and investigation with a view of assisting in clearing up some of the misunderstanding that now exists in regard to some fevers in the tropics.

BOMBAY RELAPSING FEVER

Its Etiology and Clinical Manifestations and their comparison with those of European and American Relapsing Fevers and African Tick Fever.

By Khan Bahadur N. H. CHOKSY, M.D. (Hon: Causâ) Freiburg;

Special Assistant Health Officer, Bombay Municipality, in charge of Arthur Road Infectious Diseases and Maratha Plague Hospitals, Bombay.

To Vandyke Carter belongs the sole merit of identifying relapsing fever at Bombay. It was in 1877, subsequent to the famine, that, in spite of bitter official opposition to his views, and in spite of his being twitted by the then Governor of Bombay that what he saw under the microscope were not the spirilla of relapsing fever but his eyelashes, he succeeded in demonstrating the presence of *Spirillum Obermieri* in the blood, and thus proved to the hilt that the fever then prevalent was none other than Spirillum or Relapsing Fever, otherwise called Famine Fever. Other isolated outbreaks followed, and it was during that of 1882-83, that I had the privilege of studying the disease under his able guidance. Thereafter there appears to be a hiatus in the history of this fever until 1896, when another isolated epidemic amongst the shoe-makers from Northern India was noticed early in the year. Plague manifested itself later, and after the first epidemic, an outbreak of cholera followed in its wake. A severe famine was then prevailing, and it was not long before relapsing fever reappeared. Its presence in this City was not suspected, until I drew the attention of Sir James Campbell's Plague Committee, to the fact. The cases admitted into the Arthur Road Hospital were so typical, that I had no hesitation in diagnosing them as such from their clinical features alone. As usual, it took some time to convince the authorities. Their doubts were, however, soon dispelled by the bacteriological examination of the

blood. Since then relapsing fever has figured in the nomenclature of our death-causes. For over 12 years it has persisted and still persists in our midst, mostly in an epidemic form (except in 1903, 1904 and 1908), with a seasonable prevalence usually concurrent with that of plague. The various Municipal and Plague hospitals have received over 12,000 cases during the period, the Arthur Road Hospital having had the largest number, over 7,300. It is proposed in this paper to summarise the most important etiological data, in so far as they bear upon the clinical aspects of the disease, to describe its clinical manifestations and to compare the same with those of the European, American and African varieties of the affection. I must, however, disclaim at the outset any attempt at an exhaustive consideration of the subject, inasmuch as the greater and more exacting claims of plague have not allowed of such close study of the disease as I should have desired; it is therefore with some diffidence that I venture to place before you the following resume:—

Etiology.

Relapsing fever has always been recognised as a disease of scarcity, poverty and destitution. It claims the largest number of its victims during periods of famines and great economic stress that follow upon them. It attacks the lower and lowest strata of humanity whether it be the Irish immigrant in America, the Roumanian gipsy or Jew or the Russian monjik in Europe, the African carrier in Uganda, or the poor Indian labourer, coolie or scavenger. Privation, overcrowding, insanitary conditions of life and insufficiency of food are its sponsors, and, hence, when it visits the slums of great cities, where there is no lack of suitable pabulum for it to thrive upon, is it to be wondered that it makes a fixed abode and garners its victims year after year. The main reason why it has stuck to Bombay so long, has been the recurrence of successive famines and the train of evils that they have left behind, to which must be added the large influx of immigrants that sought relief from the charity of this City, from time to time. The disease does not always occur thus. In institutions like prisons and schools localised outbreaks are not infrequent, once infection has been brought into them, for unlike plague the disease is notoriously infective and numerous instances of whole families being almost simultaneously struck down are to be met with. And as one attack does not confer prolonged immunity, it is not uncommon to see the same patient returning to the hospital for two or three years during successive epidemics.

The chief etiological factor is infection by the Spirillum, or as it is now called Spirochæte. It is the common originator of the European, American, Indian and African types of fever, and it is probable that different strains of Spirochætes are the causative agents in these varieties. It was in the European disease that Obermier discovered its presence in 1873, and Vandyke Carter subsequently confirmed it in that at Bombay. Novy and Knapp,[1] from their observations on the American fever, believe that the Spirochæte of the Bombay fever is different from that of the other fevers and that relapsing fever really consists of a group of fevers. Leishman[2], after examining films of blood from various sources, was unable to confirm the morphological differences described by them between the Spirochætes of European and Indian Relapsing fevers although he found specific differences between Spirochæte Obermieri and S. Duttoni. Captain Mackie[3] has, however, found an undoubted morphological difference between the American and Bombay Strains of Spirochætes; apart from the inactivity of the anti-serum prepared from the former against the Bombay Spirillum. The observations of Hodges and Ross[4] and Ross and Milne in Uganda, of Dutton and Todd[5] in the Congo Free State and of Dr. Livingstone, Sir John Kirk, Christy, Rev. J. Bentley, Sambon, Dawson and Daniels, on African Tick fever, leave no room for doubt that another strain of the Spirochæte, S. Duttoni, is the infective agent of that disease. Besides the above types of infection, it is assumed that the "Disease of Tete" on the Zambesi and the "Disease of Miana" in North Persia also belong to the group of relapsing fevers. Captain Markham Carter describes an analogous affection that occurred amongst the men attached to the escort of the Anglo-Turkish Boundary Commission, which bears great similarity to the African type. Prof. Ulenhoth and Hœudel[7] believe that the European, American and African strains of the Spirochætes differ from each other as each has its own specific serum-reaction. If the serum of an immunised animal is brought into contact with blood containing Spirochætes from an animal infected with the same strain, marked agglutination occurs, but not if of different strain. These observations have a practical bearing in diagnosis and on serum-therapy.

Mackie[8], in a paper read before the American Society of Tropical Medicine, has provisionally classified the European, African, Asiatic and American types of disease as being connected with four distinct species of the Spirillum,—Sp. Obermieri, Sp.

[1] Journal of Infectious Diseases, May, 1906; British Medical Journal, 1st December 1906.

[2] British Medical Journal, 23rd March 1907.

[3] The Lancet, 21st Sept. 1907.

British Medical Journal, 1st April 1905.

[5] Do. do. 11th Nov. 1905.

[6] Indian Medical Gazette, October 1908.

[7] British Medical Journal, 29th June 1907.

[8] Transactions of the American Society of Tropical Medicine, Vol. 3, 1907-08.

Duttoni, Sp. Carteri and Sp. Novyi, respectively, and compares their characters as under:—

——	Sp. Obermieri, European.	Sp. Duttoni, African.	Sp. Novyi, American.	Sp. Carteri, Asian.
Minimal Length..	12 μ.	13 μ. ..	7—9 μ. ..	12 μ.
Shape	Spiral.. ..	Open flexures.	Regularly Spiral.	Open flexures.
Flagella	Peritrichous..	Peritrichous ?.	Terminal (Novyi). Peritrichous (Frænkel).	?
Animals susceptible.	Small rodents only after passage through monkeys.	Small rodents and many animals very susceptible.	Small rodents very susceptible.	Small rodents infected with difficulty.
Course in animals..	Mild	Very severe ..	Severe ..	Very mild.
Course in man ..	One, sometimes two relapses.	Severe, four or five relapses.	? ..	Severe, one or two relapses.
Parasites in human blood.	Heavy infection.	Very	? ..	Variable
Natural Transmission.	? ..	By ticks ..	? ..	By lice (?).
Serum-Reaction ..	Immune serum without any effect on Novyi and Duttoni.	Immune serum without effect on Novyi or Obermieri.	Immune serum without effect on Obermieri, Duttoni or Carteri.	Immune serum without effect on Novyi.

He concludes that the four organisms, although closely related, are not identical, but are different varieties. There exist differences of opinion as to whether the spirillum belongs to the class of bacteria or protozoa. Novy and Knapp [9] hold to the former view for the reasons set forth by them in their article, and Mackie brings forward some fresh arguments based upon the differential leucocyte reactions of bacteria and protozoa, in support of their contentions.

The Mode of Infection.

The observations of Tictin at Odessa in 1897 led him to conclude that the bed bug (Cimex lactularius) was the agent concerned in the spread of infection. Sandwith [10] is also of the same opinion derived from his experience in Egypt especially during the prevalence of relapsing fever in the prisons. The prison walls were found infected with bug-nests, there being several thousands in a room of moderate size. Some time after the walls were properly cleaned and filled up, the fever ceased to exist. Mackie kept monkeys and bugs, fed on infected monkeys, together in specially devised cages, and although the dissection of the latter showed the presence of Spirilla in them up to the seventh day, only one monkey out of six experimented with developed the disease 11 days after first exposure to the bites of 30 fed bugs. A series of 53 bugs collected from the beds of relapsing fever patients at the Arthur Road Hospital during the pyrexial period were examined, but in the stomach of one bug only were a few spirilla found. Similarly whilst inquiring into an epidemic at a Mission Settlement at Nasik,[1] he confirmed the presence of spirilla in the alimentary tract of the bug. Fleas and mosquitoes were however found to be free from infection. In the course of this enquiry the greater prevalence of the disease in boys than in girls led him to investigate the cause, and he found that it was due to the former being infested with the body-louse (Pediculus corporis). On dissecting them, he found that the female body-louse was more infected with spirilla than the male, and the nits not at all; the stomach and the upper alimentary tract were infected, and the secretion expressed from the mouth contained abundant spirilla; 14 per cent. of the lice from boys were found infected as compared with only 2·7 per cent. from girls. Dissection of the head-louse (Pediculus capitis) showed only some sebacious matter from the hair follicles. He therefore concluded that, whilst the latter did not play any part in the transmission of relapsing fever, the former acted as a carrier, as it is able to transfer itself easily from clothes and bedding thus spreading the disease from one person to another and one place to another. Mackie, therefore, states that grave suspicion rests on the body-louse as a transmitter of relapsing fever, as its life-history and habits show that these parasites fulfil the necessary conditions for spreading the disease, prevailing as they chiefly do, amongst the poverty-stricken, dirty and low-caste people congregating in overcrowded rooms or huts. It is probable that the secretion from the louse's mouth is the medium responsible for transmission during the height of an epidemic.

African tick fever is communicated by the bite of the infected tick, or of tick born of infected females; (Ornithodoros moubata), the horse tick. Ticks are met with in the houses of Arabs in the Congo Free State, in the dust, cracks on the mud floor, in and around the bed and in the bedding. Their habits are very similar to those of bed bugs. Human beings are attacked at night or during sleep, and here too it is the female tick that is the culprit. At Colombia, South America, another species of tick (Ornithodoros turicata) is incriminated by Blanchard.

The Persian type is transmitted by a tick of a sub-family (Argas persicus). The agent concerned in the type noted by Markham Carter is also a tick belonging to the same group as the African tick; it also attacks human beings at night, in dry sandy soil, and causes enormous œdema at the site of the bite, with subsequent persistent discoloration. Sergent, Edmund and Foley[2], after investigating relapsing fever at Oran on the frontier of Morocco, came to the conclusion that mosquitoes and flies were not concerned in the infection but that Argas

[9] Journal of Infectious Diseases, 29th Dec. 1907.

[10] Transactions of the Society of Tropical Medicine and Hygiene, 1907-08.

[1] British Medical Journal, 14th Dec. 1907.

[2] Bulletin, Societ. Pathol. Exotique.

persicus and the body-louse were the possible carriers of infection. Fowls suffer from a species of similar infection, *spirochaetoris gallinarum*; the carrier of the parasite is the Argas miniatus in America and Argas persicus in the North of Africa and Persia. Fulleborn and Mayer[3] have succeeded in transmitting the disease to fowls from the African tick, Ornithodoros moubata, thus showing that at least one species of the spirochæte was capable of being transmitted by a carrier other than the one usually associated with it.

Parasitic Infection in the Human Beings.

The presence or absence of the spirochaetes in the blood during infection is variable in the different varieties of the fever. Whilst in the European type infection is heavy, in the African it is sparse, and in the Indian variable. The Sp. Obermieri are present in the blood stream from the onset of the fever until the crisis, when they suddenly and totally disappear; it is presumed that they then collect in the spleen (Metchnikoff). They are never found in the excretions. Sp. Duttoni is very sparse and much less in evidence than the other varieties. Heavy infection is, however, met with in the Arabian type (Markham Carter) Sp. Carteri are found in the blood during the acute attack, become more frequent as the crisis approaches, when they completely disappear. They are not to be seen during the secondary rebound, nor always during a relapse. And even in undoubted cases, with all the characteristic clinical symptoms, they may not be present. Vandyke Carter sometimes came across immense numbers, often incalculable except by hundred of millions. "They were often so crowded as to offer mechanical impediment to the circulation as evinced by dusky lividity of the countenance." The purple discolouration of the nose observed in European relapsing fever (J. W. Moore) is probably due to this cause. In the grave type of Indian relapsing fever, otherwise called Bilious-Typhus Relapsing, it is very heavy; McCowen[4] states that there is one spirillum to every 3—4 corpuscles. The secretions and excretions have been found to be free, except occasionally the urine, but spirilla are to be found in the menses, the placental blood, and in blood from hæmorrhages. They are not to be found in the apyrexial blood, but that the blood still remains infective has been proved, as monkeys, inoculated with such blood, develop an acute attack simultaneously with the relapse in the patient, and the appearance of the spirilla in both.[5] And blood drawn from patients one to three days previous to the expected relapse showed development of spirilla even in vitro, such development coinciding with the time of the relapse in the patient (Alrecht, Mackie and Rove). The disappearance of the spirilla during the apyrexial interval was supposed to be due to their congregation in the spleen. Lamb[6], however, has found that spleenless monkeys did not suffer to a greater extent than normal ones. He thinks that the crisis is determined, not by phagocytosis, but by the increase of spirillicidal substances in the blood; the former being of subordinate importance. According to his idea, "Spirilla escape by finding areas protected from the full spirillicidal pressure of the blood, and remain there until such pressure has been reduced by excretion or by the production of anti-spirillicidal bodies. They then are able to recultivate themselves in the blood stream and so produce a relapse." (Mackie.)

Animal Infection.

The susceptibility of rodents and other animals to infection has been already referred to. Mackie has found the following animals susceptible to infection with Bombay spirillum: Monkeys, white mice, white rats, black rats (mus rattus) and brown rats (mus decumanus) and guinea-pigs in order of susceptibility. Markham Carter has succeeded in conveying infection to the local bush-tailed rats from infected human blood. Infection can take place through the unbroken skin in mice. Albert Bohene reports[7] a case where the patient's blood, though free from infection for a month, was capable of infecting mice; and also similarly blood of inoculated mice, though free, was found capable of infecting other mice. Mackie succeeded in transmitting the disease to a monkey by repeated punctures from an infected monkey by means of a grooved needle or artificial proboscis. Freshly drawn infected defibrinated or citrated blood behaved similarly. Feeding the monkey with infected blood resulted in infection, but the dose was larger than by subcutaneous injection and the period of incubation prolonged. The spirilla sometimes found in the urine of infected patients fail to infect lower animals. A monkey was infected with blood from a patient who was in the apyrexial period, and whose blood was free from spirilla. Five days after the monkey was infected, the patient developed a relapse, and the monkey the primary attack simultaneously; spirilla appeared in the blood of each, and the disease ran its usual course. Mackie, therefore, concludes "that (a) the spirillum remains in the circulating blood in an unrecognised or ultra-microscopic form; (b) that the blood is infective during the apyrexial as well as the pyrexial period; and (c) that there is a definite cycle of development which comes to a crisis with the appearance of visible spirilla at definite intervals."

Active and Passive Immunity and Serum-Therapy.

Novy and Knapp have succeeded in hyperimmunising rats and they find that a powerful ger-

[3] Archin: für Schiffs und Tropen Hygiene.
[4] Indian Medical Gazette, October 1906.
[5] *Vide* infra.
[6] Scientific Memoirs by the Medical Officers of the Army in India, 1901, Part 12.
[7] Archin. für Schiffs und Tropen Hygiene. Jour. of Tropical Medicine.

micidal body is present in decline and recovered blood. Some of their most important conclusions bearing upon clinical medicine are:—

"Activo immunity follows upon an infection and can be increased to a remarkable degree by successive injections of spirillar blood. Passive immunity on the other hand can be imparted by injection of recovered or hyperimmunised blood. Both active and passive immunity can last for months. Preventive inoculations can be successfully made in rats, mice and monkeys. Infected rats, mice and monkeys can be promptly cured by injection of hyperimmunised blood. There exists thus a solid basis for the prevention and cure of relapsing fever. The agglutination, germicidal and immunising properties of recovered blood can be used in the serum diagnosis of relapsing fever, and also for the identification of spirilla.

Mackie prepared a serum at Bombay by repeated injections of spirillar blood into a monkey. It produced sloming and agglutination of the spirilla in a dilution of 1 in 20 in 15 minutes with complete cessation and commencing lysis in one hour. This serum was used to inject a patient at the Arthur Road Hospital; 20c.c. were injected intravenously on the third day of his relapse; until the evening the temperature remained high and the spirilla did not decrease or diminish though the leucocyte rate rose. The temperature fell from 104° to 97°F, 22 hours after the injection, and 64 hours after the beginning of the relapse, the leucocyte count falling from 40,000 per cubic millimeter to 80,000 and thereafter the patient remained normal. There were no ill effects and no second relapse. The brother of the patient, one year younger, admitted on the same day with relapsing fever and in the same stage, suffered from fever for one day longer, subsequently went through a typical second relapse. It is impossible, says Mackie, to draw any conclusion from a single case, but the result is encouraging. These observations open out a new field of inquiry into the serum-therapy of the disease.

Immunity after Infection.

The duration of immunity acquired after an attack is not very prolonged. Vandyke Carter himself sufferod more than once, as also Anna Moreshwar Kunte who assisted him in his investigations. Sir Robert Christison had three separate attacks within 15 months (1817-19). Recurrent attacks among patients are not infrequent, and the same patient returns to hospital during two or three successive epidemics. Some of the attendants at the Arthur Road Hospital have become even severely infected more than once. Dutton, who discovered the spirochæte of African tick fever, himself succumbed to it.

Racial Incidency of Relapsing Fever at Bombay.

The greatest sufferers are the low-caste Hindus and next to them the labouring classes comprising mill-hands, coolies, dock labourers, etc., almost all Hindus. Among 7,131 admissions at the Arthur Road Hospital, the Hindus numbered 6,502, Mahomedans 503, and Native Christians (mostly Goans) 117. The disease is very rare among the better classes of all communities. I have not observed more than a dozen cases among Parsees.

Mortality.

An extremely low rate of mortality has characterised the epidemics in Europe. At the London Fever Hospital, among 2,115 cases, treated between 1848-1870, the mortality rato was 1·84 per cent. only.[1] Murchison has recorded 4·03 per cent. in 18,859 cases, and the average arrived at by Rabagliati[2] was only 5 per cent. The American cases do not exhibit any variations, and Austin Flint[3] says that the usual mortality is between 2—4 per cent.; it has been sometimes found to be as high as 10—11 per cent., and higher still in the bilious type. Moffat mentions the fact that on the Zambesi the typo of fever is very severe, the carriers sometimes succumbing to the extent of 50 per cent. On the other hand, Dutton and Todd state that the mortality is not severe in Uganda and the Congo Free State except under fatigue and exposure; Harford[4] supports this on the authority of Drs. A. R. and J. H. Cook, who have recorded it at 13·6 per cent. among 66 cases. In marked contrast to the above, the Bombay type has been characterised by a high mortality rate. Vandyke Carter has recorded 18·02 per cent., and McCowen 20·25 per cent. The recent epidemics at Bombay have, however, beaten these records. The average mortality rate among 7,131 cases was 30·7 per cent., although it has varied during different epidemics. In the early days, in 1897 and 1898, it remained between 15—20 per cent. in 2,045 cases, but after the great famine it rose to as high as 43·80 per cent.: subsequent to 1902 it has oscillated between 30—39 per cent. Successive famines with all their attendant sequelæ, chronic destitution, insufficiency of food, and clothing, herding together in overcrowded tenements, together with an unprecedented prevalence of phthisis amongst the victims of relapsing fever, in the majority of whom the infection gave but the final *coup de grace* to their existence, were the chief contributory causes of this heavy mortality. To these should be added from 15—20 per cent. of the cases of the Icteric or Typhus-Bilious type with an extremely high death rate.[5] And finally the total lack of all care, nay, even absolute neglect, prior to admission into hospital and the state of collapse and almost moribund condition in which a large pro-

[1] Eruptive and Continued Fevers, by Sir John W. Moore.
[2] Sir Clifford Allbult's System of Medicine, Vol. I.
[3] A Treatise on the Principles and Practiec of Medicine, by Austin Flint, M.D.
[4] Transactions of the Society of Tropical Medicine and Hygiene, 1907-08.
[5] McCowen reports 66·6 per cent. among 18 cases observed by him at Sirur, between Poona and Ahmednagar.

portion of patients are brought for treatment, account for a great deal of the fatality. If the infection is however localised under rather better circumstances as in prisons, the mortality is very low; it did not exceed 5 per cent. among the convicts (over 300) from the Bombay jails, treated at the Arthur Road Hospital. Although the average rate of mortality was 30·7 per cent., it was 30·3 per cent. among Hindus, 35·1 per cent. among Mahomedans, and 36·7 per cent. among native Christians. As regards sexes, 73·7 per cent. were males, 17·7 females and 9·0 children; the mortality rate among males and females was exactly equal, 32·1 per cent., but in children it was considerably less, 16·1 per cent.

Clinical Manifestation.

The European variety of relapsing fever has been graphically described by Murchison, Aitken, Moore, Rabagliati and others. The clinical manifestations do not materially differ from those of the Indian variety, except in so far as the greater preponderance of the graver type of infection—the Icteric or Bilious-typhus in the latter, and the absence of serious complications in the former—are concerned. All the principal features of the Indian type are reproduced on a minor scale with but few differences, such as the lesser frequency of diarrhœa, hæmorrhages, parotitis, and delirium. Griesinger has recorded his observations at St. Petersburg on the bilious-typhus type which closely resembles that observed at Bombay, the most prominent symptoms being abdominal, with grave jaundice, intense prostration, coldness of the extremities, low muttering delirium, and purple discolouration of the nose, the pyrexia being not so high as in the ordinary type.

Austin Flint[6] has well described the American type; it is characterised by fewer relapses, infrequent jaundice, moderate bilious vomiting and diarrhœa, and more frequent epistaxis than in the above. The occasional presence of the bilious-typhus type is also recognised. The disease does not greatly differ from its European prototype, and has an equally low fatality.

To Dutton and Todd, Hodges and Ross, Ross and Milne, A. R. Cook and J. H. Cook, Harford, Greig and Nabarro, Moffat, Sambou, Sandwith, Rev. Bentley, Christy, Dawson and Daniels, Bagsham, Baker, Manson and others, we are indebted for descriptions of the African Tick or Relapsing Fever in Uganda, the Congo Free State, on the Zambesi and in Egypt. Compared to the above types it does not appear to be a severe infection, unless under circumstances of great stress and exposure. In its clinical manifestations however there exist certain characteristics that stamp it as a distinct entity. The short duration of its individual paroxysms, the greater frequency of relapses from three to five and the consequent prolongation of the illness are some of its principal features. In all other respects, such as the intensity of the various symptoms, its complications and sequelæ (those of the eye excepted), it exhibits much milder traits than the European and American varieties. Its greater fatality is presumably due to the undue length of the illness, consequent upon numerous relapses.

The Indian variety[7] of relapsing fever with which the name of Vandyke Carter has been indissolubly connected presents some features that distinguish it as the gravest form of spirochætosis; it is certainly more severe and more fatal than any of the above. The circumstances under which it has prevailed at Bombay indicates that given the necessary favourable conditions, a disease so markedly characterised by its mildness in Europe and America becomes transformed into a severe and more fatal infection. Its clinical manifestations could be best discussed under separate heads.

The Pyrexia.

With or without a few premonitory symptoms of general malaise, headache, etc., the illness is ushered in with a rigor, followed by rapid elevation of the temperature, which may rise to 105° on the first day. It is lower generally, not attaining to the maximum till the fourth, fifth or sixth day; remissions of one or two degrees in the morning and exacerbations in the evening characterise this period. Rigors are not infrequent and the patient is often noticed to perspire profusely. The highest temperature is reached on the evening of the sixth day, either as a steady continuation of the previous exacerbation, or there may be a remission followed by a sharp elevation before the crisis; in the latter event, the temperature reaches as high as 106° to 109° F. The pyrexia lasts for six days, the crisis occurring on the seventh but occasionally on the fifth or sixth day (charts 1 and 2.) Within a few hours, the temperature rapidly declines; the drop varying from 5° to 13° or even 14° sinking to 96° or 94° or even 92° within a few hours. The patient becomes cold, collapsed, and is bathed in profuse perspiration. The period immediately prior to and after the crisis are the most critical, as many deaths occur at the time. Simultaneously with the fall of temperature, the frequency of the pulse becomes greatly reduced, the pulse rate of 120—140 before the crisis, falling to 70, 60, or 50 or even lower. Should the pulse fail to correspond with the crisis, it means either rapid death, some complication or more probably an immediate rebound of the fever. Exceptions to the above course of the crisis are not uncommon: the fall may be gradual, being divided into 2—3 stages of 2° to 3° each, prolonged over

[6] "Principles and Practice of Medicine" by Austin Flint.

[7] Markham Carter states that the fever observed by him in Arabia resembles somewhat the African type being characterised by a short incubation period, headache, boneache, intense prostration, lack of mental activity, enlargement of the spleen, terminal copious greenish diarrhœa, and a slow return to comparative health.

2 days (chart 3); occasionally the temperature falls by lysis (charts 4 and 5). The latter chart also shows the gradual step like elevation of the first relapse extending over 4 days, the apyrexial interval between the two being 5 days. Diarrhœa often precedes or follows upon the crisis. The European and American varieties of the disease do not at all differ from the Indian type as regards the initial or invasion attack. But, in the African type, the first paroxysm lasts for about three days only, occasionally from 4—5, and the attack is much milder than in any of the above.

Within a few hours after the crisis, the patient feels warmer, the low subnormal temperature rises slowly, and there is a remarkable improvement in his general condition. In the majority of cases it is continuous and steady, the temperature oscillating between 97°-98°, the pulse gradually creeps up to its normal frequency, the diarrhœa, if any, ceases, the urine becomes light coloured, the patient loses his dusky, care-worn or haggard look, the appetite returns and may be even voracious. It is surprising to notice how, within three to four days of the crisis, the patient desires solid nourishment, relishes and digests it as well. Such is the normal course when the infection is moderate and uncomplicated. It is under these conditions that the fever is characterised by its extremely insignificant mortality of 2·5 per cent. In about 25 per cent. of cases, however, the relief does not last long, and by the evening of the same day, there is a rebound in the temperature which may rise as high or even higher than prior to the crisis; it remains so for a few hours and is followed by a second crisis (chart 6), the temperature again falling to subnormal. Thereafter the patient enters into the apyrexial stage without any further mishap. The second crisis is not without danger to the patient, as death from collapse from the violent fluctuations of temperature within a few hours is not infrequent. The duration of the rebound or secondary fever may be prolonged to 3—4 days (chart 7) when the appearance of the temperature curve is likely to be mistaken for a double attack. Or, again, it may not develop till 48—60 hours after the crisis (chart 8) and follow any of the above courses. No spirilla are found in the blood during this stage, inasmuch as it is due to toxæmia resulting from the bacteriolysis induced by the spirillicidal substances elaborated in the system. Happily for the patient this toxæmia is of short duration, the toxins are soon eliminated, and he enters into a state of rapid convalescence that may or may not lead him on to the relapse.

The above course becomes greatly altered in about 15—20 per cent. of the cases; the toxæmia is more profound as the infection is heavy from the beginning. It is to this phase of the disease that the name of Icteric, Typhus-Bilious or Bilious-Typhus-Relapsing fever, has been applied. Vandyke Carter frequently met with it; it has been observed in Europe and America, and in the course of the last 12 years it has been frequently noticed at the Arthur Road Hospital in the above proportion. How far it is justifiable to label it as a distinct type is a moot point, for after all it is nothing beyond the manifestation of toxæmia in those cases in whom the spirillar infection is very severe. As such it is characterised by symptoms of grave import. The patient is deeply jaundiced from the beginning; the conjunctiva of deep yellow, with the network of injected capillaries overlying it, presents a weird appearance; incessant and frequent vomiting of bile or of dark coffee-ground matter, the urine deeply tinged with bile pigment, violent or low muttering delirium, fairly high pyrexia lasting for 6—7 days, and constipation. The crisis occurs at the usual period but there is no improvement thereafter in the condition of the patient, the frequency of pulse remains high and there is either an immediate or step-like rebound in the pyrexia (charts 9, 10, 11, and 12). In the former instance the temperature may rise to 105°—106°, oscillating thereafter for 7—10 days or longer, and falling by lysis to normal, the patient recovering without a relapse (chart 9).[1] In the latter, it becomes incorporated with a severe relapse, the temperature rising to 104°—107°, the patient succumbing either immediately before, during, or after the crisis (chart 11). Where the rebound is gradual by distinct stages, it is generally rather less severe and what ought to have been the apyrexial interval is curtailed to 5—6 days, a relapse in continuation occurs, the temperature falling by crisis and the patient enters into convalescence (chart 10). On the other hand, it may follow a course similar to that seen in chart 11, with frequent remissions, the temperature gradually rises, and death supervenes within 8—10 days, or longer after the rebound (chart 12). Whatever the course the toxæmia pursues, the clinical manifestations are alike in each. The patient becomes extremely prostrated, there is rapid wasting; the decubitus is dorsal with the thighs drawn up, torpor or almost semi-coma, low muttering delirium, intense pain and tenderness over the epigastric region, over the liver and spleen, which are felt much enlarged, severe tympanites causing dyspnœa and embarrassing the circulation, a brown and fissured tongue, sordes on the lips and gums, persistent constipation, hiccough, an extremely feeble and thready or even dicrotic pulse, coldness of the extremities, the features dusky or cyanotic, subconjunctival hæmorrhage, keratitis or iritis or even destructive inflammation of the eyes, hæmorrhages such as

[1] McCowen states that the temperature was never higher than 102° in his cases, and that it usually fell by lysis; this was due probably to the system being unable to adequately react to the stimulus of the infection, on account of its gravity, and the consequent interference with the balance of heat production and heat elimination.

hæmaturia, hæmatemesis, melæna, or epistaxis, and pulmonary symptoms from stasis, congestion and œdema of the lungs. In fatal cases, these symptoms become more and more grave every day, until the patient sinks into deep coma and succumbs. Those unconversant with these aspects of relapsing fever often mistake this state for enteric. No spirilla are to be found in the blood during toxæmia. The patient is however highly infectious during the initial or invasion attack if there be profuse epistaxis or other hæmorrhages and the bed linen or clothes are soiled with the infected blood. The source of infection among hospital attendants and sweepers is often to be traced to such cases. Should the patient recover, as some 15—20 per cent. do, convalescence is very slow, marasmus from the combination of the toxin with the tissue-cells of the body often results; also great prostration and wasting; and polyneuritis with trophic changes in the bones and joints. Mackie has investigated the causation of the grave jaundice in these cases; he also thinks that it is due to toxæmia. The toxin causes extravasation of blood and hæmolysis: the hæmoglobin, thus set free, is conveyed to the liver, and this directly or indirectly leads to jaundice. He has found free iron in the lungs, in the spleen, and also in the liver in marked excess. The above data therefore confirm the conclusion that the so-called bilious-typhus variety of relapsing fever is but a grave and more intense infection by the spirillum than that ordinarily met with.

The Relapses.

In all other cases where the apyrexial interval is normal, the patient becomes convalescent without any further relapse, or a relapse occurs at varying intervals. In the European variety one to two relapses occur. The average duration of the first relapse being usually 3—4 days and of the second 2—3, the apyrexial intervals lasting from 7—10 days in each case. The American type is not always characterised by relapses although 2—5 relapses have not been unknown. The African Tick fever, on the other hand, has always 3—5 relapses, and as many as 11 have been recorded. The apyrexial interval extends from 7—8 days, and rarely from 10—18 days.

The Bombay fever, as observed by the present writer, does not exhibit any relapses in about 50 per cent. of cases; one relapse has been noticed in 40 per cent.; two relapses in 7 per cent. and three or more relapses in 3 per cent. The regular typical relapses are often replaced by abortive relapses that develop just about the time that a relapse is due, the temperature being suddenly elevated for a few hours, and falling as rapidly by crisis. One or two such abortive relapses are not uncommon (charts 13 and 14). The apyrexial interval between the primary attack and the first relapse is variable, and 'may extend from 5 to 19 days. The most frequent intermission lasts 7 days and then, in order of frequency, 8, 9, 10, 6, 5, 11, 13 to 19 days.[1] Immediately prior to the relapse, the patient feels somewhat uncomfortable, and his aspect becomes dull. The elevation occurs sharply or in two stages, and often without a rigor; sometimes it is preceded by a distinct depression of 2 or 3°; that is pathognomonic of the impending relapse which lasts from 3—5 days, occasionally longer. Remissions are noticeable during its course, and there is usually a sharp rise before the crisis (charts 15, 16, 17 and 18), which may be as severe, or even more so than that of the primary attack. The same phenomena are observed as before rather milder in intensity, but not invariably so; diarrhœa and delirium may be present. The patient recovers rapidly after the crisis, and there may be no further relapse, or one, two or even three abortive relapses thereafter (charts 16, 17 and 18). Should the relapse become prolonged over 6—7 days (chart 19), or should it be followed by an immediate rebound and secondary fever, with interrupted crisis (charts 20 and 22) or after a crisis (charts 21, 22 and 24), toxæmia sets in and is characterised by the same symptoms as those delineated after the first paroxysm with the exception of diarrhœa which is present in more than half the cases, of tympanites not so grave, and of parotitis, single or double, generally suppurative. The bilious-typhus manifestations thus reappear after a relapse under identical conditions, and prove equally fatal, without the previous attacks foreshadowing such a development. In this way the relapse becomes often more dangerous than the first paroxysm from the infection becoming graver. The fatal cases (charts 20 and 22) bear a close resemblance to charts 11 and 12, the only point of difference being the change of period in the onset of toxæmia—after a relapse, instead of the primary attack. The irregular secondary fever in the two cases who recovered (charts 21 and 23) was due to suppurative double parotitis, not an uncommon complication at this stage of the disease. Pneumonia too is more likely to prevail and death often takes place when the toxæmic fever becomes merged into a fresh relapse (chart 24). Convalescence is prolonged and marasmus may occur.

A second relapse occurs in about 7 per cent. of cases: it most frequently develops 8 days after the crisis of the first relapse, and thereafter in the following order of frequency—5, 11, 12, 7, 10, 6, 8, 13, and 14—17 days. The intervals between the first paroxysm and the first relapse and that between the latter and the second relapse are always variable, the usual tendency being for the former to be more prolonged. Occasionally they may be of equal duration. The second relapse may be more severe

[1] Murchison (quoted by Sir J. W. Moore) gives the following averages:—

Primary attack	... ...	5·96 days.
Intermission	... ...	7·82 „
Relapse	... ...	3·45 „

than the first (charts 25, 26, 27) with a longer duration and higher range of temperature. It may or may not be accompanied by diarrhœa. Chart 27, besides showing the two relapses, exhibits equal apyrexial intervals between them as also the unusually prolonged course of the initial attack lasting 9 days. Abortive relapses sometimes intervene between the first and the second relapse, during the intermission (chart 28), or about the usual period of the appearance of the latter (chart 29), followed by another intermission, thus prolonging it to over 19 days.

Three and more relapses have been noticed in about 3 per cent. of cases only. The intervals between them are variable and so also is the course of fever (chart 30). Two or more relapses may follow after the first, in spite of the latter being prolonged through toxæmia, with a very short interval between it and the following relapse, and the latter may be also severe (chart 31). Another rare type of infection is that in which relapses of short duration are to be seen almost continuous, with scarcely any interval (chart 32), all being comprised within 17 days. The following chart (chart 33) similarly exhibits a case with four distinct but short relapses, with hardly any appreciable interval, the total course extending to 17 days and ending fatally, without any complications, except almost continuous and violent delirium. The four relapses may be, on the other hand, separated by typical apyrexial intervals, and yet they may be only abortive relapses occurring at the period when the relapses are actually due (chart 34). Numerous irregularities are to be found when the relapses exceed two, both as regards the duration of each relapse and the intervals between them (chart 35). Five relapses, irregular, with toxæmic symptoms after the second relapse, the whole illness extending over 74 days, and terminating fatally during the acme of the last relapse, are to be noticed in chart 36. Five almost continuous relapses are very rare; the case (chart 37) had profuse hæmatemesis on admission, double suppurative parotitis, prolonged diarrhœa, and secondary fever, and it terminated fatally on the 55th day of illness.

Malaria and Phthisis with Relapsing Fever.

The association of malaria, either following after the invasion attack without a recurrence or intercalated between two relapses is not uncommon. Charts 38 and 39 illustrate the benign tertian type during the apyrexial interval, and chart 40 the quartan type, followed by an abortive relapse. In addition to the above typical forms of relapsing fever, a certain proportion of cases are observed non-malarial in their origin, exhibiting an irregular type of fever, but with clinical manifestations resembling those of relapsing fever, and with occasional presence of spirilla. Some of these are associated with phthisis in an advanced stage.

Other Mixed Infections.[1]

Relapsing fever also occurs in the form of mixed infection with plague, chicken-pox and cholera. These infections result from the varying periods of incubation in the diseases; plague with its incubation period of 3—4 days becomes easily engrafted upon a patient incubating relapsing fever, per contra a patient incubating chicken-pox may be infected with relapsing fever; and lastly a patient in the apyrexial stage of relapsing fever may become infected with cholera. The temperature curves under these circumstances become atypical, but the clinical features of relapsing fever and the presence of spirilla leave no room for doubt as to their nature.

The Circulatory System.

The circulation is not gravely affected in ordinary cases. The pulse is quick (100—120), somewhat compressible, but steady and of a fair volume. It remains in this state until the outset of the crisis when a sudden change for the worse is apparent: it becomes more frequent: and of very low tension. Death from syncope is not uncommon at this period. With the fall in temperature there is a corresponding fall in the pulse rate: it sinks to 70, 60, 50, or even lower, the lowest observed has been 40. It is a slow and rythmic pulse, of good volume. Sudden collapse and death are frequently encountered after the crisis also. The low pulse-rate is often a diagnostic sign when the patient is seen for the first time after the crisis. With gradual improvement in the condition of the patient the frequency increases slowly day by day, and reaches to normal about the time the relapse is due: it may be even above normal just prior to it. The depression in the temperature noted above, together with the greater frequency of the pulse, and slight dulness in the appearance of the patient, are pathognomonic of an impending relapse. Whenever the infection is grave, as also when toxæmia exists, the pulse is what we ordinarily associate with acute degeneration of the myocardium:—that is an extremely quick and feeble pulse, of low tension, irregular intermittent even dicrotic. It is not often that death from sudden heart failure occurs, but it is a contingency to be always remembered. All cases where the pulse rate is subnormal demand absolute rest, though the patient scarcely realises it and fancies himself strong enough for exertion, so rapid is the general recuperation shortly after the crisis. Equally rare is sudden cardiac syncope during convalescence.

The Respiratory System.

Bronchitis with profuse yellow tinged sputum is a frequent complication; broncho-pneumonia and lobar pneumonia are to be noticed when the infection is grave; the pneumonic sputum is also tinged

[1] In one instance a patient was found to have triple infection, malarial parasites and spirilla being found in the blood simultaneously with the bacillus pestis recovered from the bubo.

yellow. Hypostatic congestion and œdema of the lungs from stasis are concomitant; dyspnœa, and cyanosis, indicating deficient oxygenation of the blood, are common in toxæmia. The frequency of respirations is slightly increased in ordinary cases, but with grave infection, accompanied by the above complications and tympanites, it is very high. Respiratory distress is extreme with severe tympanites. Epistaxis occurs in 10—15 per cent. of cases; it may be profuse or scanty; it appears in the course of the first paroxysm or just before crisis: it often recurs during the first relapse; and occasionally it is noticed during the intermission only. It is one of the clinical signs of diagnostic import. Hæmoptysis is a rare complication. Patients suffering from phthisis appear to be peculiarly liable to spirillar infection. The symptoms become greatly aggravated and they almost invariably succumb.

The Alimentary System.

The tongue is usually clean, moist and flabby, this appearance with a high temperature being pathognomonic. In grave infection or in neglected cases it becomes dry, brown, often almost black, scaly and fissured, with sordes on the gums and teeth. The lips too are often fissured, and covered with herpes. Difficulty of deglutition from paresis of the muscles is to be noticed in grave infection. Appetite is lost, but very rapidly regained during the intermission; it is then occasionally voracious, but free indulgence often sets up diarrhœa. Vomiting of bile is the most frequent diagnostic sign and exists in 70—80 per cent. of cases; it is often profuse and of the characteristic colour, or green; and is often rebellious to treatment. Hæmatemesis, or coffee-ground vomiting is to be met with in about 2 per cent. Hiccough is another distressing symptom, often persistent, and resists all measures to alleviate it. Tympanites is more often than not severe, with pain and tenderness over the hepatic and splenic areas, the abdominal walls are tense and tender; distinct enlargement of the liver and spleen are noticeable. Jaundice is present in 70—80 per cent. of cases; it is usually mild, except under grave infection, when the whole body becomes deeply tinged. Intestinal hæmorrhage and melæna occur in about 2 per cent. Occasionally hæmorrhages are simultaneous from different organs and profuse epistaxis with hæmatemesis, melæna and hæmaturia are encountered in a single individual. Abortion with profuse hæmorrhages is also to be noticed in pregnant females concurrently with the above; all such cases end fatally. Constipation in the early days and during grave toxæmia is the rule: but usually bilious or greenish diarrhœa sets in just before the crisis, and persists throughout the intermission; it may or may not recur with the relapses. It rapidly exhausts the patient, especially if debilitated by privation, and as it does not yield readily to treatment, it is one of the most frequent causes of death. It exists in about 12 per cent. of cases. Parotitis appears during the intermission, and occasionally subsequent to a relapse. If single and of moderate extent, pyrexia is not present, but if accompanied by considerable periglandular infiltration, the temperature becomes elevated and the gland on the opposite side becomes similarly affected, the face and neck are then swollen and œdematous, and œdema of glottis may supervene. Double parotitis is generally fatal before suppuration is complete. If single, resolution takes place in about half the number and the rest suppurate requiring incision. Parotitis in relapsing fever is liable to be mistaken for plague; and patients are often removed to hospital under this impression. On careful inquiry however it is always possible to arrive at their true nature. Occasionally ischio-rectal abscess is met with in debilitated as also in phthisical subjects.

The Genito-Urinary System.

The urinary secretion is generally scanty, the urine being less limpid, high coloured, and tinged with bile pigment in 80 per cent. of cases. The tint varies from light to deep yellow, yellowish green or yellowish brown, brown, to deep brown, or almost dark or it may be green or dark green from the presence of biliverdin. In grave cases, there is hæmaturia, and the admixture of blood with the bilious urine is often observed. Hæmaturia occurs in about 3—5 per cent. of cases, and stands next to epistaxis in frequency. Nephritis with dropsy is a sequela in relapsing fever.

Abortion or miscarriage is the rule in pregnant women; it is not so fatal to the mother as in plague. It occurs during the first paroxysm; the contact of fresh infected blood is liable to cause infection among the staff and attendants. Several such instances have occurred at the Motlabai Hospital. Menorrhagia and premature menstruation are also often present.

The Nervous System.

The patient appears rather dull and apathetic with a heavy expression during the first paroxysm; headache and pains in the limbs and loins, bones and muscles are of common occurrence. The speech becomes somewhat affected in grave cases, the words being drawn out in syllables, with or without stammering. Plague is likely to be suspected under these circumstances. Restlessness and insomnia are frequent. In about half the number of cases delirium is observed; it becomes more pronounced about the fourth or fifth day of illness. It is generally confined to frequent attempts at sitting up or getting out of bed and wandering with incessant shouting, or abuse. It may become frenzied and maniacal, dangerous alike to the patient and to those near him. It is sometimes more vehement than in plague. Physical restraint becomes absolutely necessary, otherwise there is no

saying what the patient would be up to. The worst phase occurs just prior to, or is concomitant with, the crisis but once the temperature falls the embodiment of vigorous physical energy becomes as listless and helpless as an infant. He has scarcely any strength left, is unable to talk above a whisper, and has to be fed and looked after with much care. Within a day or two, there is a remarkable recuperation and he looks himself again. Similar delirium, should a relapse occur, is not frequent. In a few instances violent delirium appears only during the apyrexial period; the simultaneous presence of subnormal temperature, low pulse and loud delirium is a feature peculiar to this disease. William Robertson is reported to have observed such cases in an epidemic at Edinburgh. Vandyke Carter calls it "the delirium of inanition." It lasts throughout the apyrexial period, but subsides no sooner there is elevation of temperature from the relapse. But rarely it is of the muttering type, and, herein, relapsing fever differs from plague, as the apyrexial delirium of plague is almost always of the low muttering type. Mania often persists after recovery, as a sequela, but is not unamenable to treatment. On the other hand, delirium of the low muttering type is generally associated with grave infection, the patient lying on the back in the state already described, prostrate and feeble to exert, and gradually drifting into coma; death is not infrequently preceded by convulsions. Tremors, subsultus, and other indications of prostration are observed in this state. Symptoms of meningeal irritation with retraction of the head and back are occasionally met with. Patients are often capable of great exertion during the primary paroxysm; Vandyke Carter had noticed people walking into Bombay from long distances with pyrexia of 103°—104°; such too has been my experience; and herein the disease bears a striking resemblance to plague. Severe and acute pains in the limbs are characteristic of this fever; and pains in the muscles may persist for years after recovery. Patients often complain of a burning sensation in the soles of the feet. Hyperæsthesia, chiefly restricted to the flexures, the axilla and groin, has been looked upon at the Arthur Road Hospital as a diagnostic sign. It is however equally a source of error should there exist old, indurated and enlarged lymphatic glands. The hyperæthesia is so pronounced that on the least pressure, the patient shirks and is then declared to be suffering from plague. A notable instance of this kind once occurred in connection with one of the Bombay prisons. On the death of a convict suffering from undiagnosed relapsing fever, the death was presumed to be due to plague, and three other convicts with fever were then transferred to the Arthur Road Hospital as suffering from plague. One of them however expired in the course of the night, and, as the others appeared to be suffering from relapsing fever, the corpse was examined, and old, indurated and enlarged glands were found in the groin. As the patient had distinctly winced on pressure on account of hyperæsthesia when examined in the prison, he was declared to be suffering from plague. The diagnosis of relapsing fever among the other patients was confirmed by the presence of spirilla in their blood. In the meanwhile wholesale inoculation had been begun at the prison. The above cases were the precursors of over 200 others. When patients recover from grave infection, they sink into subacute marasmus characterised by great wasting of muscular, and adipose tissues, polyneurites, and trophic changes in the bones and joints. Convalescence is slow and occasionally death from cardiac syncope occurs from over-exertion. Epileptic seizures are apt to recur with greater frequency and severity in those subject to spirillar infection during the paroxysm, as also during apyrexia, and sometimes there is a run of such cases.

The Special Senses—The Eyes.

Dr. Mackenzie of Glasgow has described (1843) two distinct stages in the affections of the eye in relapsing fever, *the amaurotic* and the *inflamatory.* Estlander (1863) subsequently pointed out that the starting point of the disease was in the choroid, especially in the ciliary body. The toxæmia appears to cause some inflammation which thence spreads to the vitreous body, causing amaurosis, and later on to the iris causing iritis and iridocyclitis (Sir J. W. Moore). The acute degenerative inflammation leads to complete disorganisation of the structures of the eyeball, with total loss of vision from enveleation. The non-affected eye has to be carefully watched and protected. Austin Flint records a peculiar form of ophthalmia in the cases observed by Dubois in New York. Moffat, Harford and the Cook brothers have also reported frequent and severe affections of the eye associated with the African type of fever. Similar affections have also been noted at Bombay, but their frequency is not great, about one per cent. Total loss of vision in one eye is the usual result, as patients come in too late to allow of proper measures in the early stage. Simple conjunctivitis, and Keratitis are, however, more frequent, and amenable to treatment. Patients often complain of dimness of vision, without any external inflammatory symptoms or pain in the eyes, due probably to partial opacity of the vitreous. Sub-conjunctival hæmorrhage in large patches is present with or without other hæmorrhages and if associated with a deep yellow conjunctiva is highly pathognomonic.

The Ears.

Deafness is often complained of; when the parotid is inflamed and suppurates, it may discharge through the external auditory meatus.

The Cutaneous System.

Profuse perspiration is very frequent in relapsing fever, in spite of a high temperature. Suda-

mina are largely to be found, covering the trunk and abdomen. Herpes facialis and labialis is by no means infrequent. Petechiæ are rarely to be observed, but minute red spots not unlike them are noticeable. Pupuric spots are rare. Boils and pemphigus like bubbles crop up during convalescence. Sensations of heat, and burning in the skin are not uncommon.

The Osseous System.

Pains in the bones and joints and in the muscles and fasciæ are not uncommon; acute arthritis is a rare complication.

The principal death causes are cardiac syncope during the acme of the attack or from collapse during crisis; hæmorrhages, abortion, pneumonia, dysenteric diarrhœa, exhaustion, toxæmia, nephritis and antecedent phthisis.

Conclusions.

Any comparison of the clinical manifestations of the various types of relapsing fever in greater detail than what has been attempted here would be too prolix for practical use. The statement herewith appended compares the principal features in the European, Indian, American and African varieties. It is conclusive from the tabulation that the African Tick fever though a variety of relapsing fever is not identical with any of the other types.

Whilst characterised by shorter duration of individual attacks, the number of relapses is far greater than what prevails in the other types; the complications and sequelæ are never so grave and its fatality though heavier than in its American and European prototypes, occurs, be it noted, in people who have no strain of European blood in them, who are exposed to laborious avocations involving extraordinary physical exertion, and whose habits and mode of life are anything but sanitary. Given the

	European.	Indian.	American.	African.
Incubation period	5-7 days	7 days	5-7 days	7-10 days.
Duration of first attack ...	5-6 „	5-7 „	5-6 „	Average 3 days (rarely 4-5)
Duration of apyrexia ...	7-10 „	5-13 days; occasionally up to 19 days.	7-10 „	1-8 days (occasionally 10-18)
Number of Relapses ...	1-2 „	1 relapse in 40 per cent., 2 in 7 per cent. and 3 and more in 3 per cent.	One (rarely 2-5) ...	3-5 „ (sometimes upto 11).
Relapses absent	?	In 50 per cent.	Not uncommon ...	?
Rigors and sweating ...	Present	Very frequent	Present	Rigors in 50 per cent. only: sweating present.
Pains in limbs, muscles, etc.	Do.	Do.	Do.	Frequent.
Toxæmia (Bilious-Typhus type).	Mentioned...	Present in 10-20 per cent...	Mentioned	?
Low pulse rate after crisis...	Present	Almost invariably present.	Present...	?
The Tongue	Large and moist except in grave infection.	Large, flabby and moist except in grave infection.	Large and moist except in grave infection.	?
Appetite	Poor—sometimes voracious	Poor—rarely voracious ...	Poor	?
Jaundice	Mild—except in grave infection.	Present in 70-80 per cent.; grave in toxæmia.	Mild, except in grave infection.	Infrequent in Uganda.
Vomiting of Bile	Not uncommon	Present in 70-80 per cent...	Not uncommon ...	Not usual.
Diarrhœa	Of brief duration	Present in 12 per cent. ...	Moderate	Always in the Congo: infrequent elsewhere.
Tympanites	Grave in toxæmia ...	Invariably associated with toxæmia.	Grave in toxæmia ...	?
Hiccough	Present	Often persistent	Present...	Mentioned.
Hæmorrhages from stomach and intestines.	Not frequent	More frequent than in the other varieties.	Not frequent	?
The Liver	Enlarged	Enlarged and tender ...	Enlarged	Enlarged.
The Spleen	Do.	Do. do. ...	Do.	Do.
Parotitis	Mentioned	Present in about 10 p. c....	? ...	?
The Urine	High coloured; scanty ...	Highly bilious; scanty ...	High coloured ...	?
Hæmaturia	? ...	? More frequent than other hæmorrhages.	? ...	?
Epistaxis	Mentioned	Present in 10-15 per cent...	More frequent than other hæmorrhages.	Mentioned.
Pulmonary symptoms ...	Do.	Present; more so in toxæmia.	Present...	Do.
Delirium (violent)	Do.	Not uncommon; also maniacal.	Do.	Infrequent.
Facial Paralysis	?	Not observed	? ...	Mentioned.
Eye affections	Mentioned	Present in about 1 p. c. ...	Mentioned	Frequent (Moffat, Harrord and Cook.)
Sub-conjunctival hæmorrhages.	?	Not uncommon	? ...	?
Abortion and miscarriage ...	Observed	Always	Observed	Almost always.
Mortality rate	Very low; under 5 per cent. except in grave infection.	30-40 per cent. in all cases; if toxæmic cases are excluded 15-20 per cent.	2·4 per cent., rarely 10 per cent higher in toxæmia.	13·6 per cent. (?) about 50 per cent. on the Zambesi (?) probably lower.

same conditions and circumstances of infection as in European or American, its fatality would, I think, be infinitissimal.

It is not so easy on the other hand to point to such marked differences among the other three varieties. The Bombay type appears on the whole to be more virulent, and, although it exhibits some variations from the European and American types, these are of degree rather than kind. The similarity is so striking that I am almost tempted to suggest that these variations might owe their origin to the differences of climate and race altering the environment of the identical strain of the spirillum, and rendering it more malignant and less susceptible to resistance in the tropics, as compared with the temperate climates in Europe and America. Whether the morphological differences observed by Novy and Knapp, and Mackie between the Ame-

Chart No. 1. Chart No. 2.

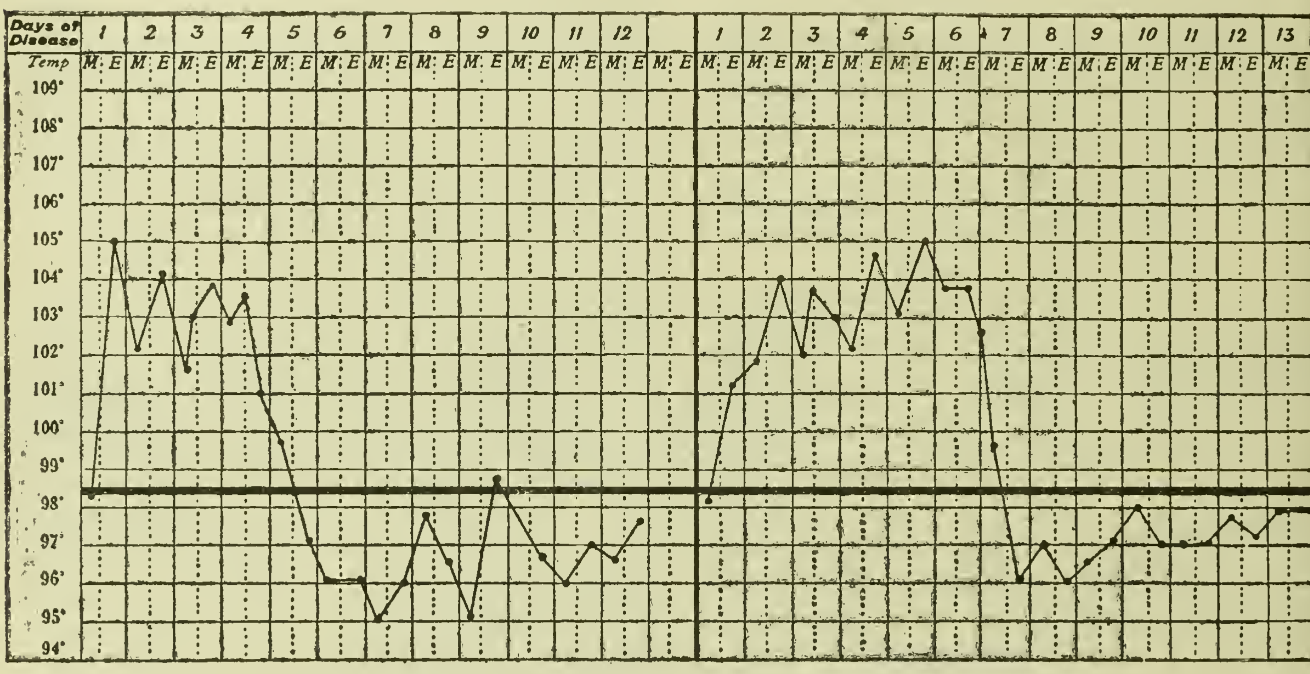
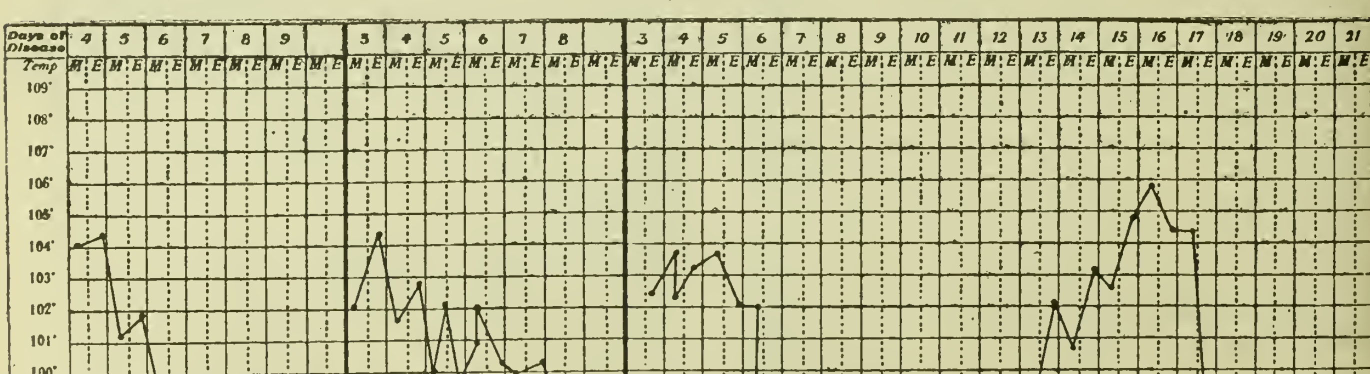


Chart No. 3. Chart No. 4. Chart No. 5.



rican and Indian strains could be thus accounted for, I would leave it to others, more competent than myself, to indicate. Is it too much to infer that other affections common to different parts of the world are similarly affected by such conditions? Whatever future investigations in regard to the specificity of the different strains of the spirochætes associated with these varieties of relapsing fever might bring forth, some crucial observations by transplanting the Indian strain to a colder climate and studying its behaviour, under infection under modified conditions, are necessary to elucidate how far one and the same strain of the organism is capable of altering its infectivity for the better or worse in accordance with the environments in which it may be placed.

Chart No. 6. Chart No. 7. Chart No. 8.

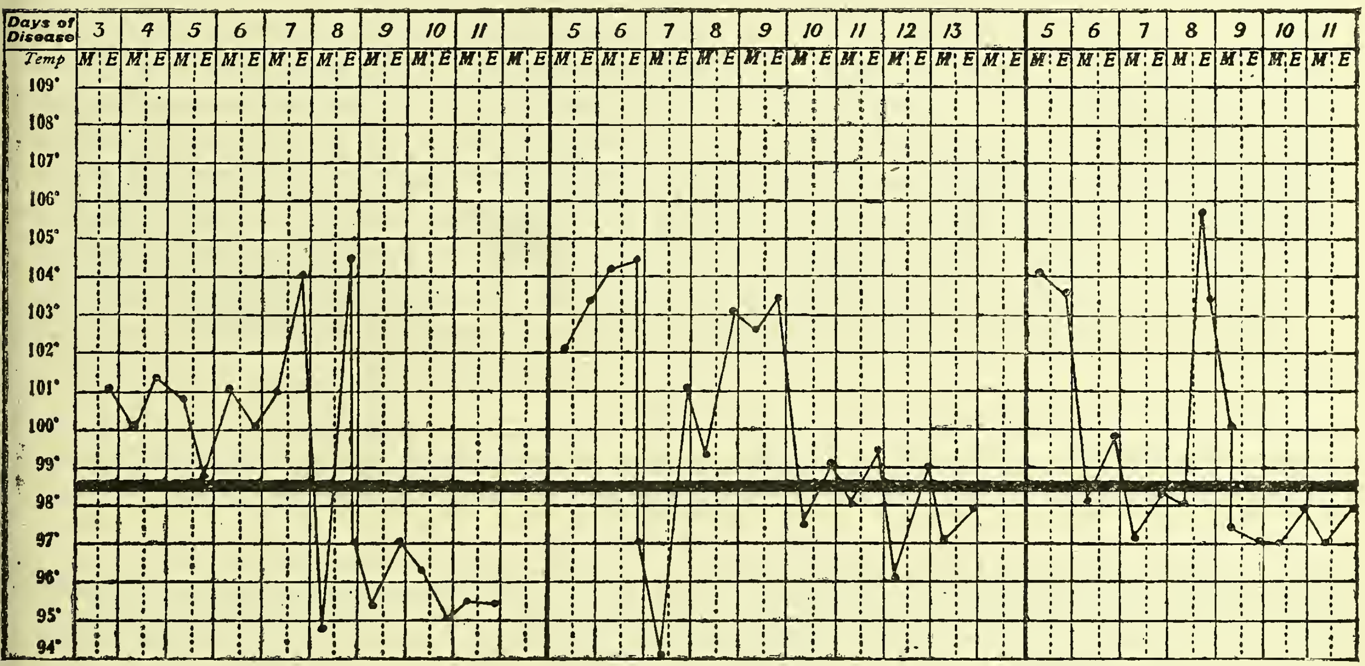


Chart No. 9. Chart No. 10.

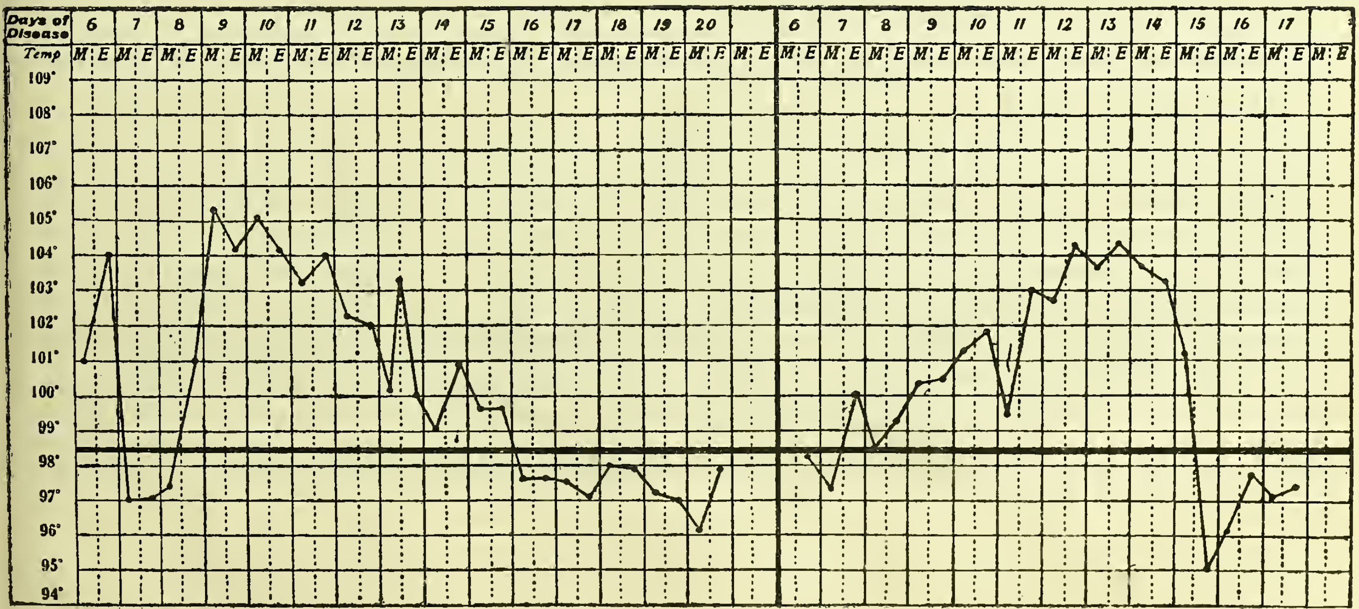


Chart No 11. Chart No. 12.

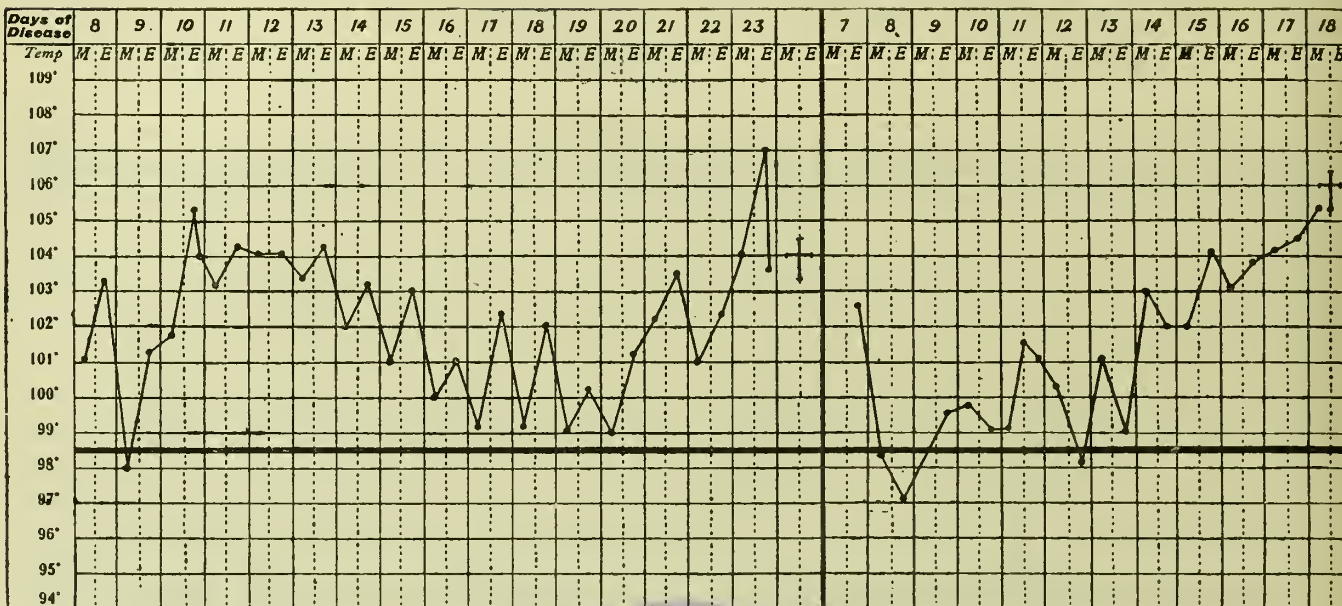
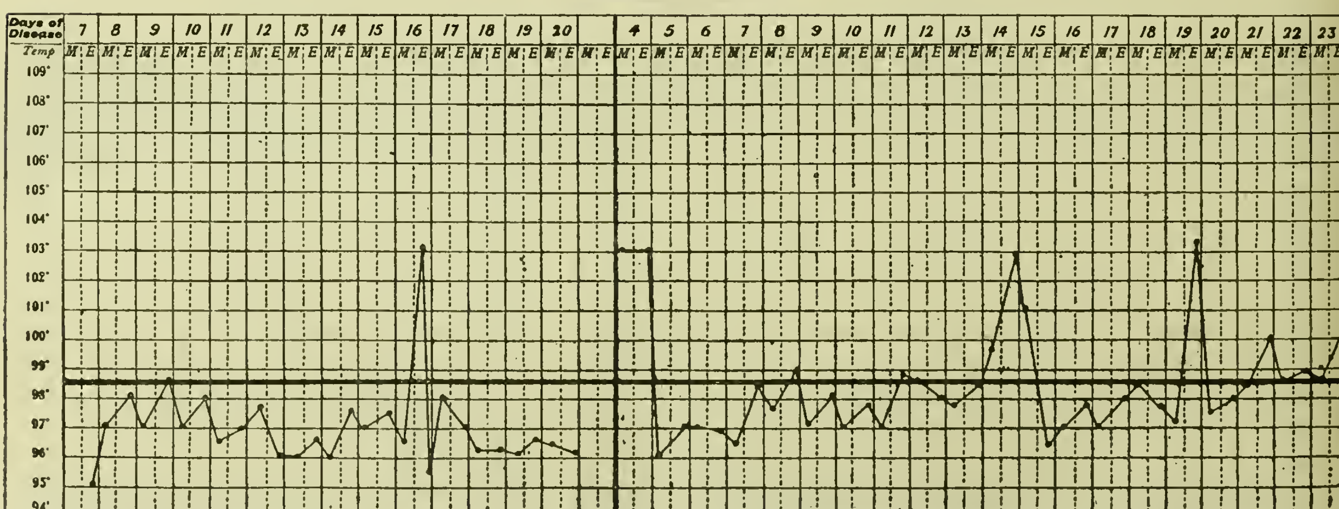


Chart No. 13. Chart No. 14.



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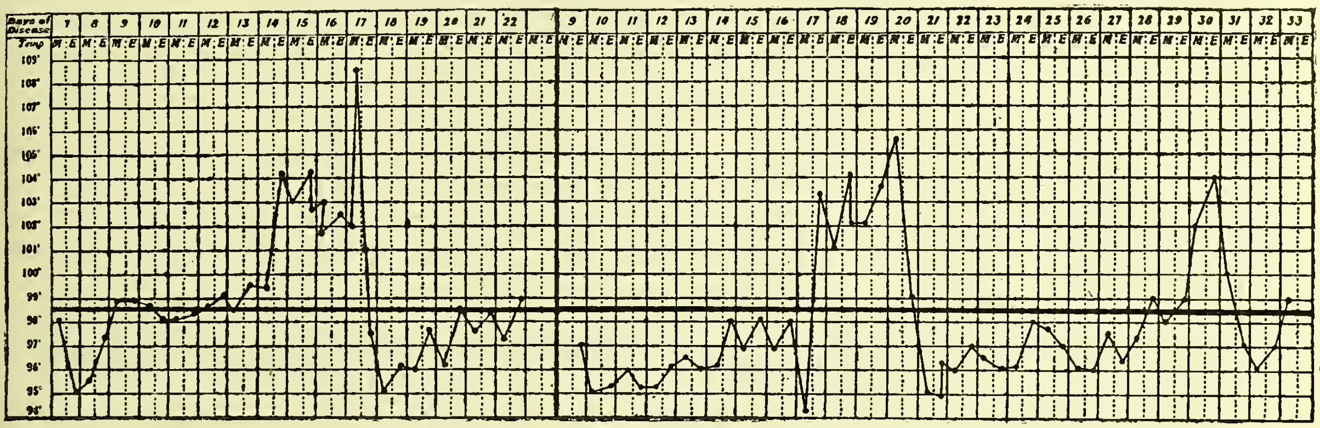

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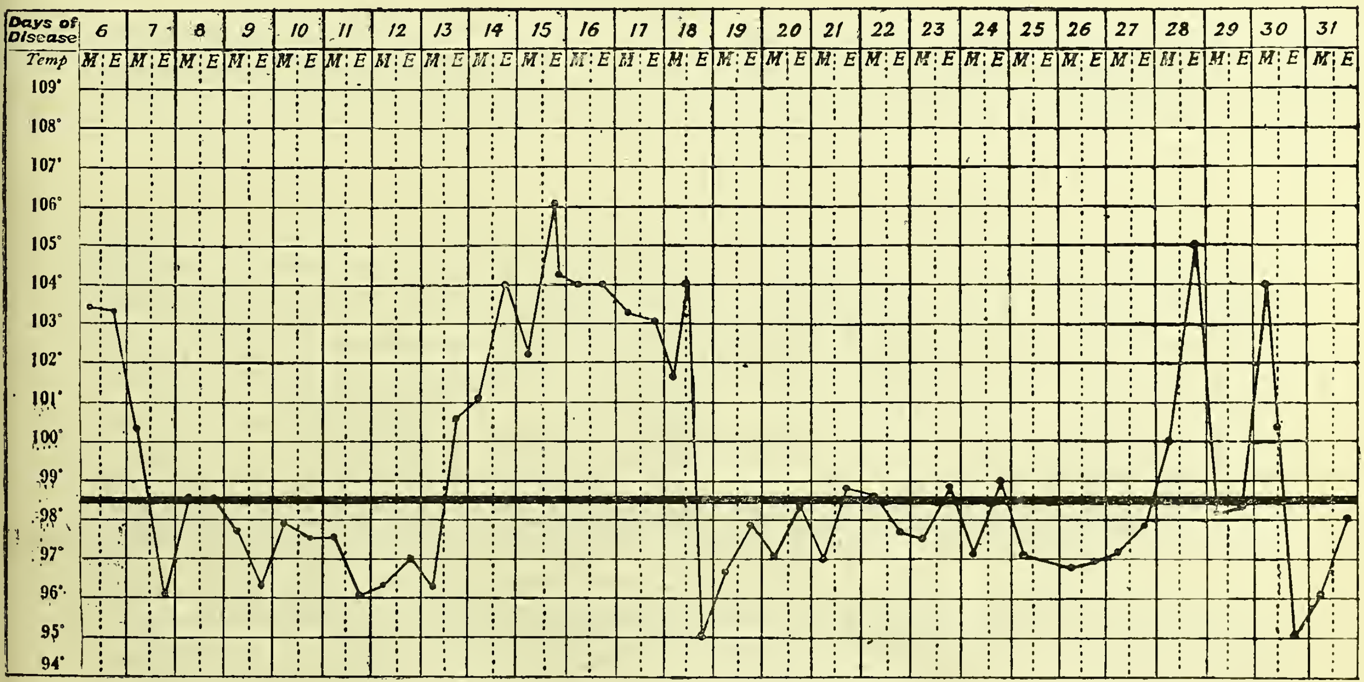

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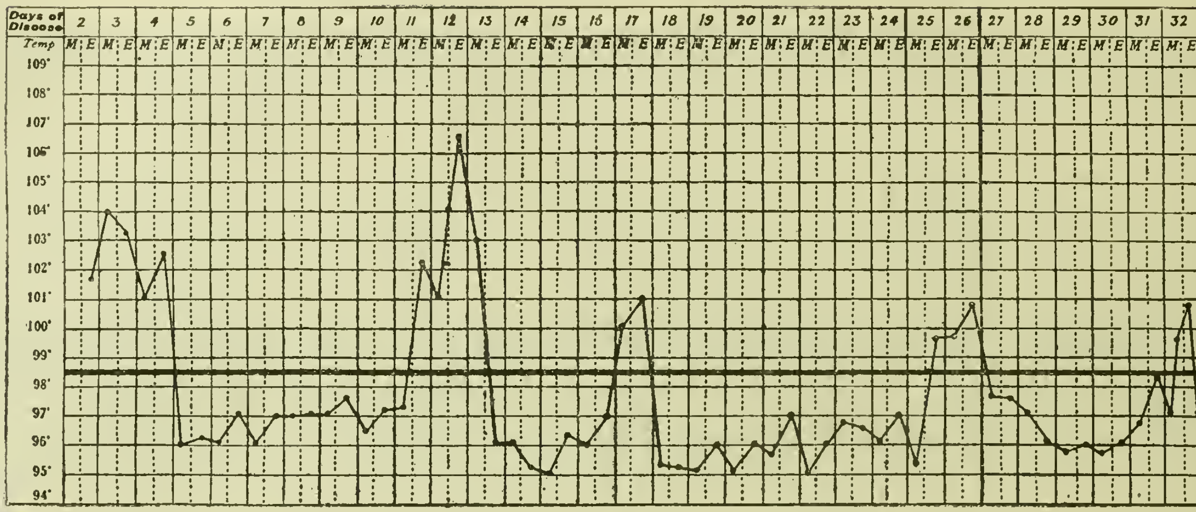

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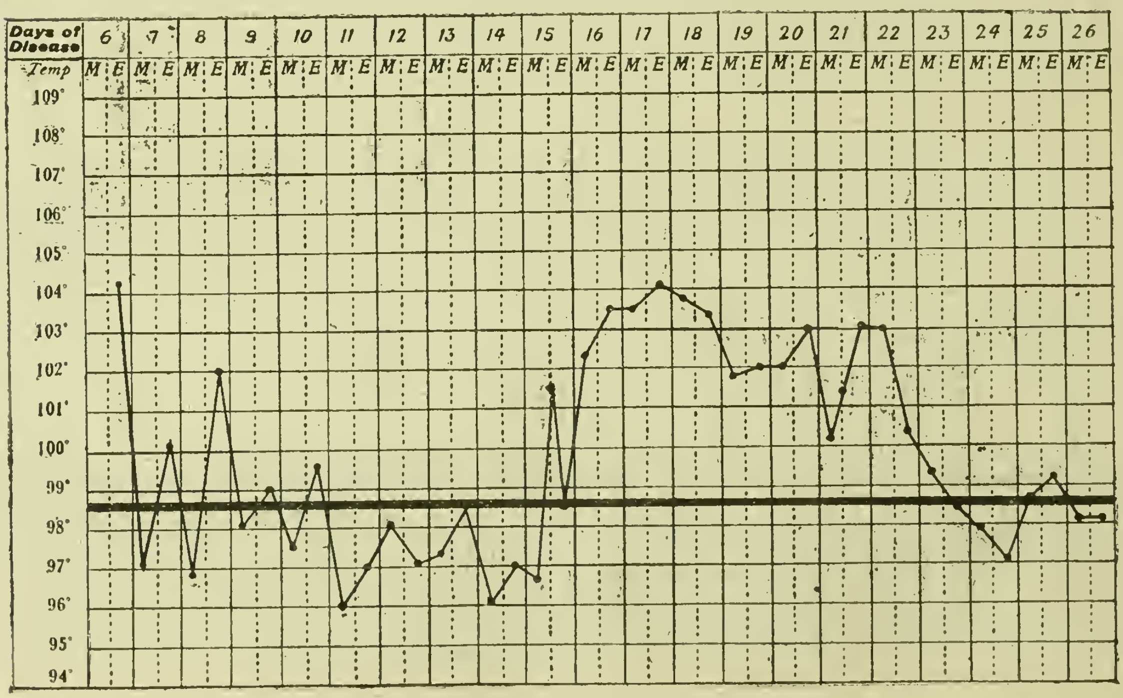

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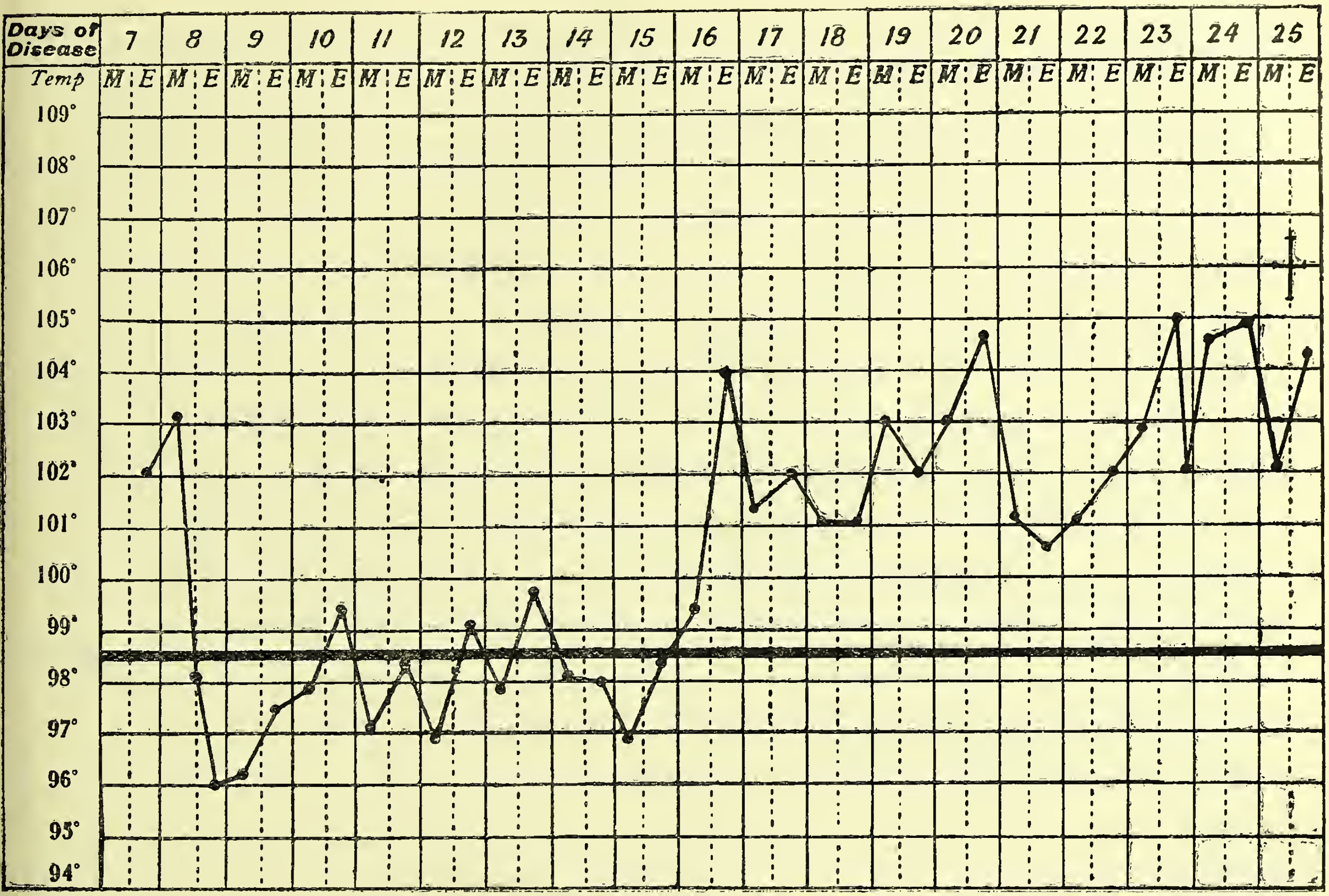

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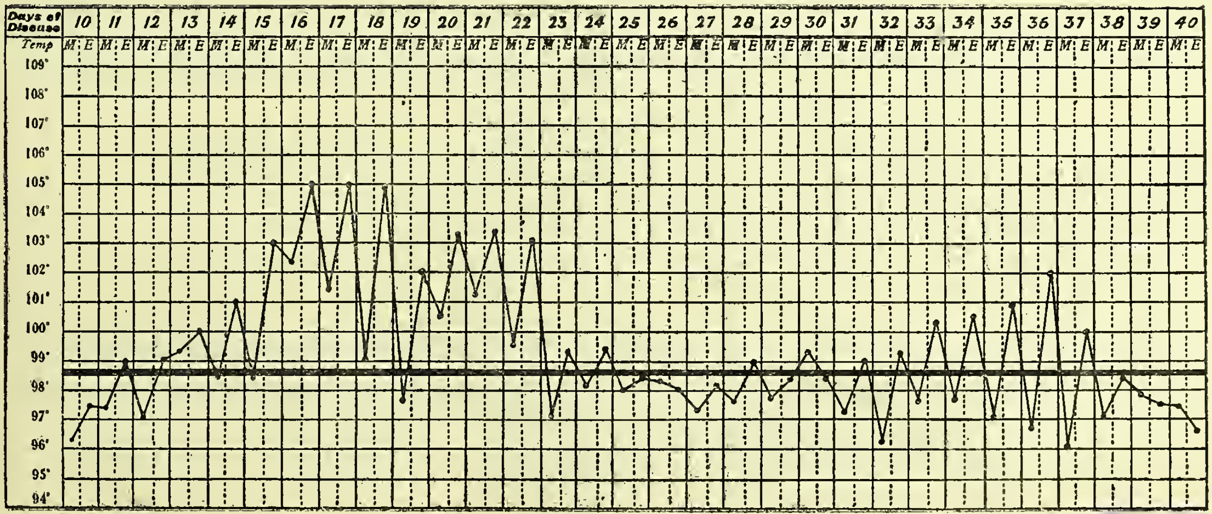

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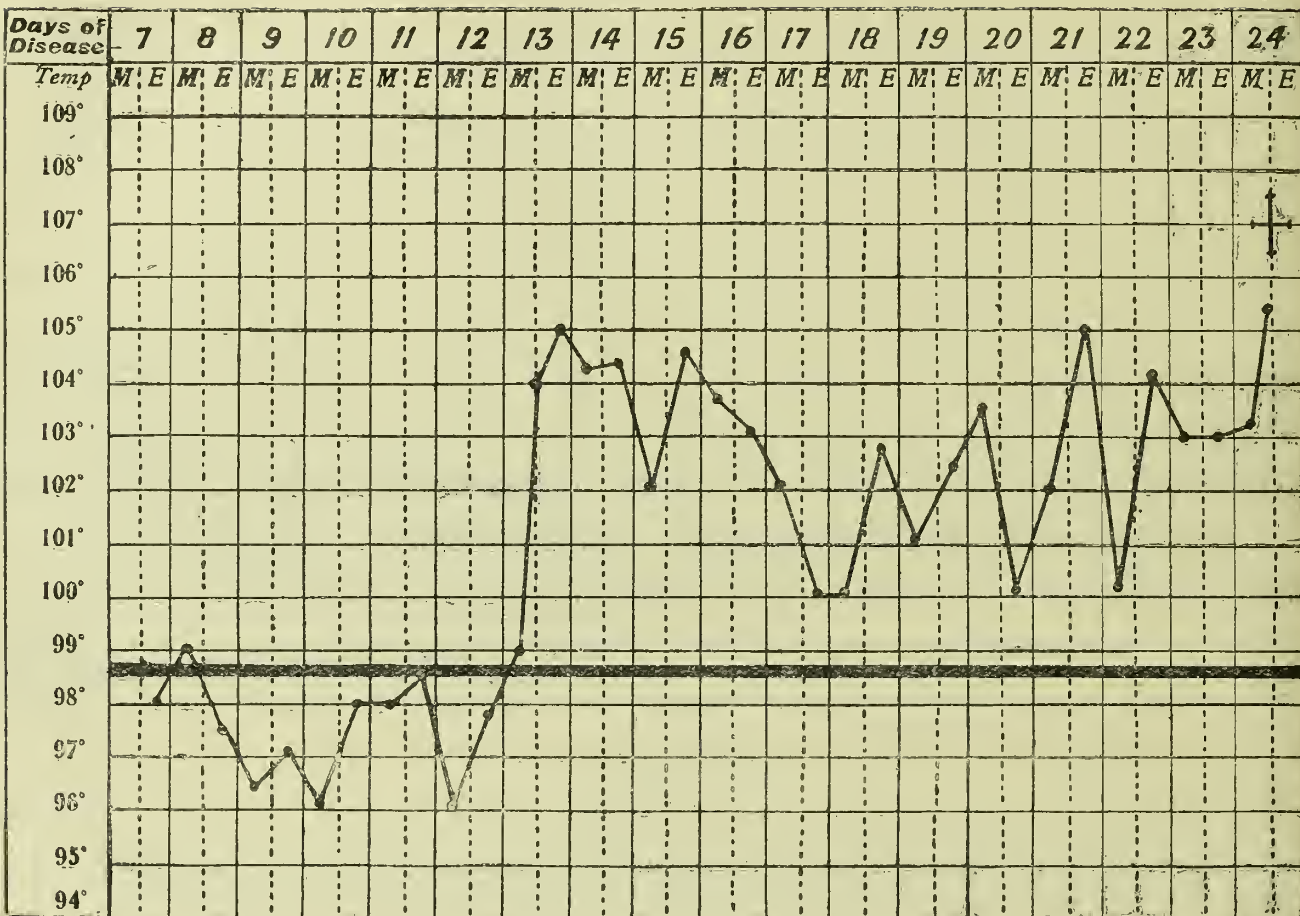

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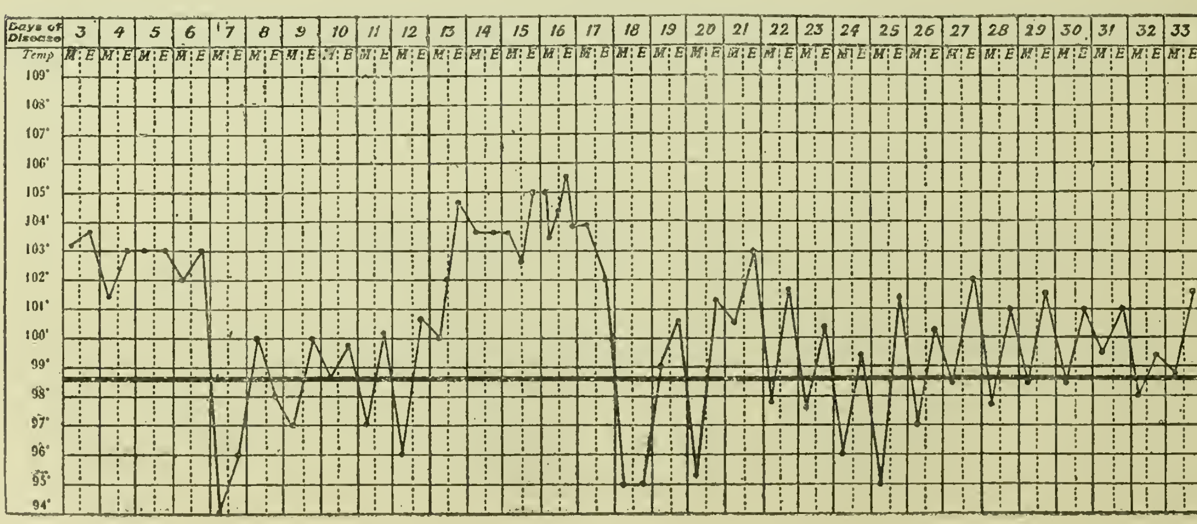

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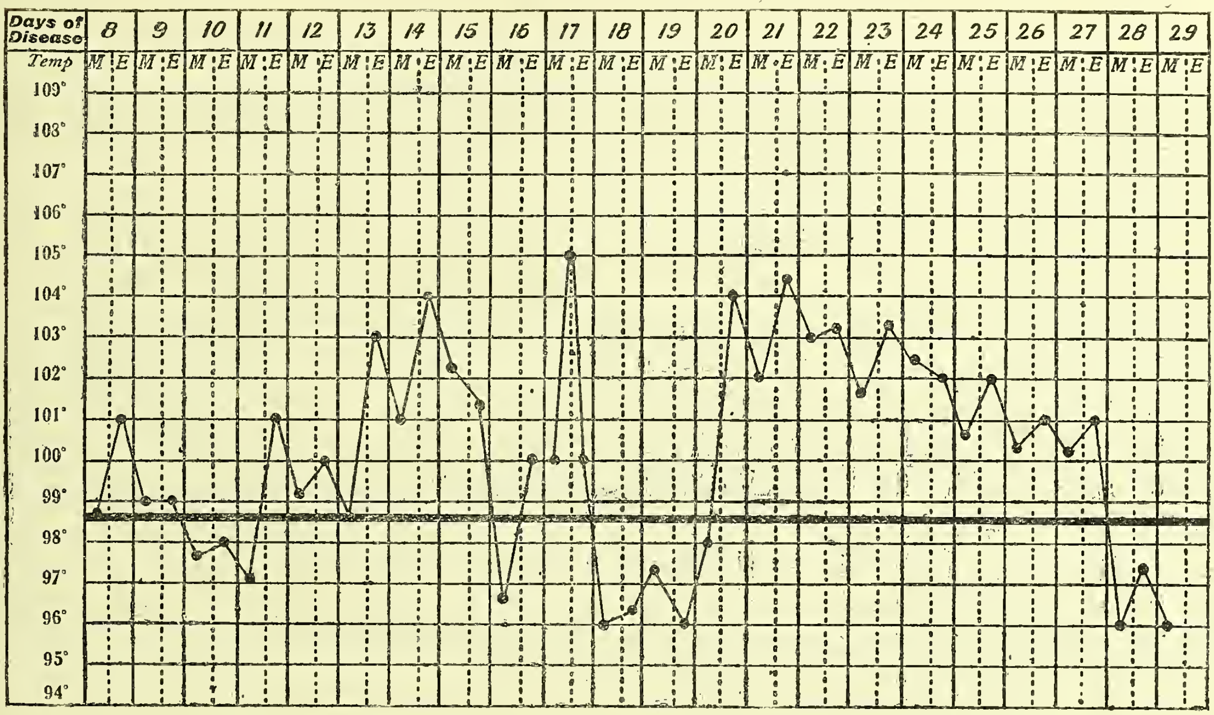

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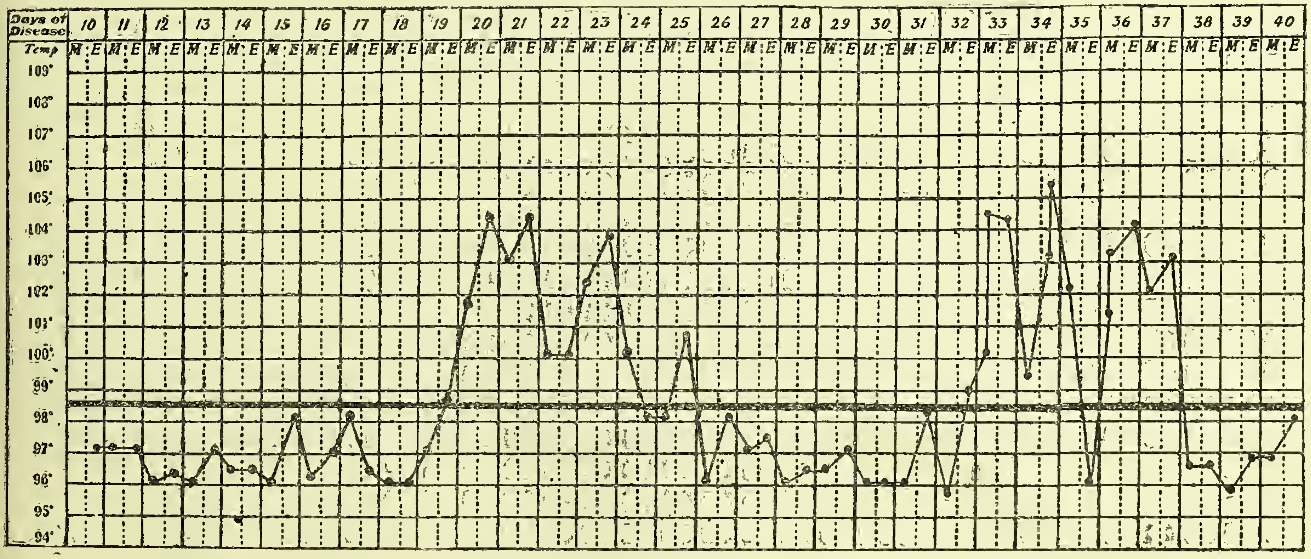

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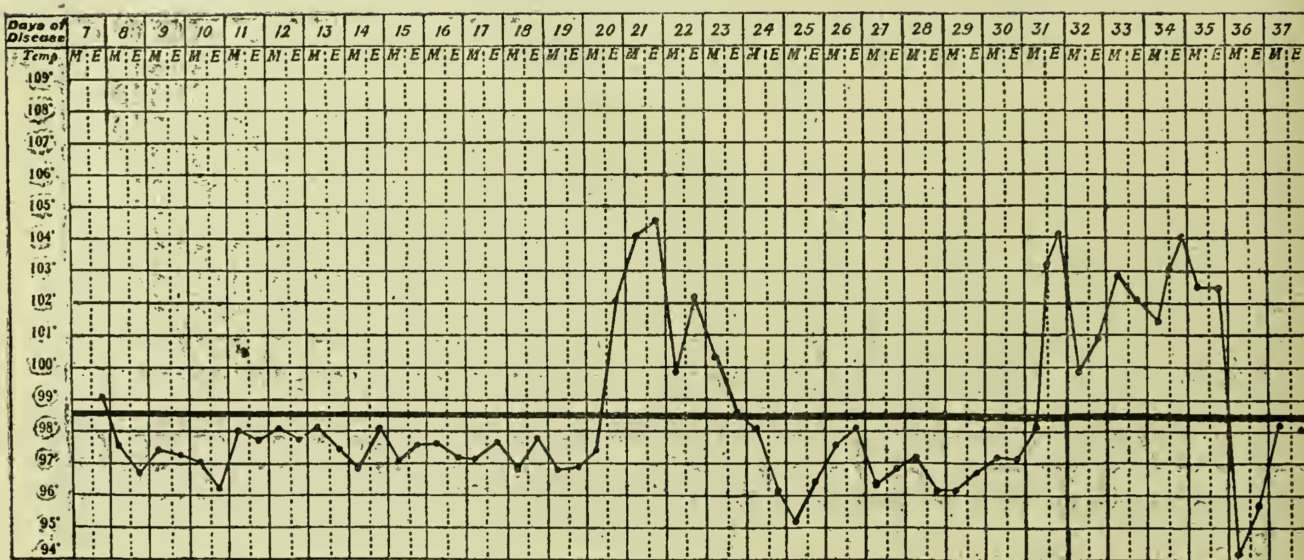

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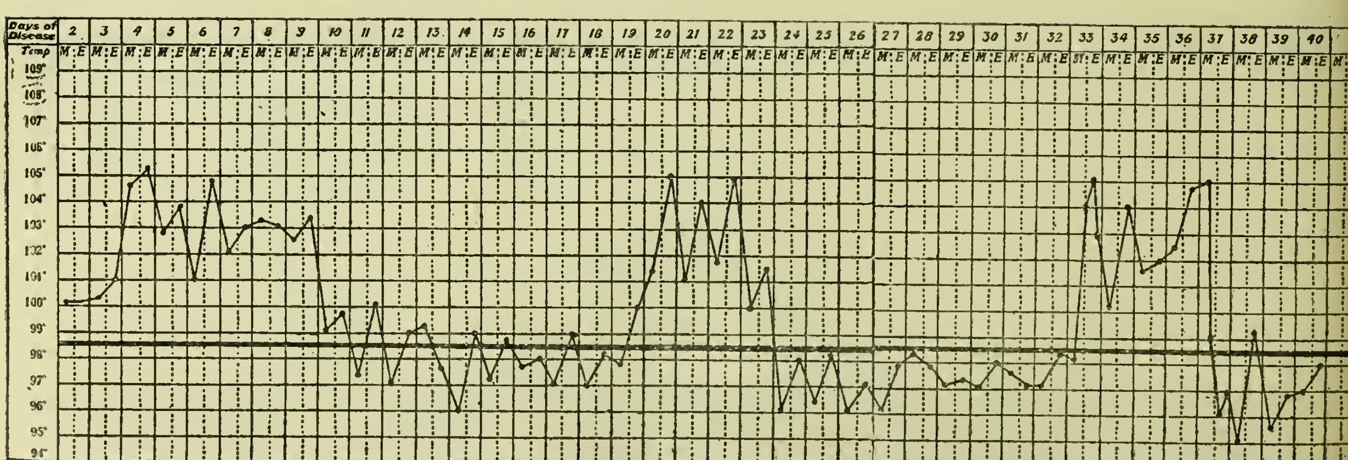

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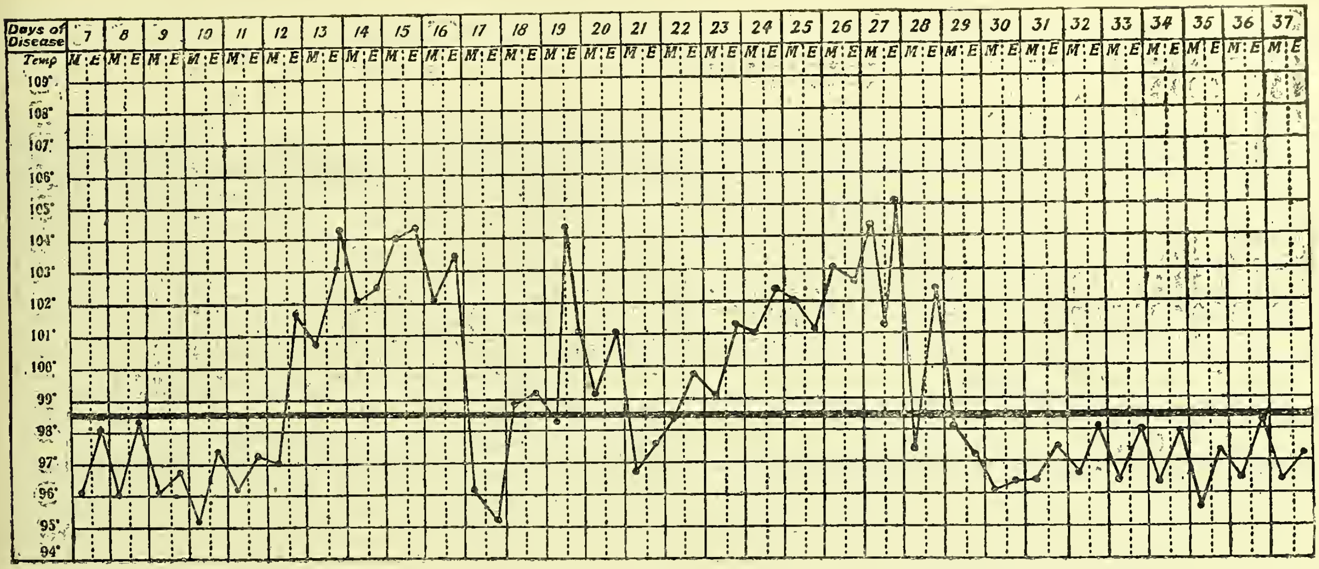

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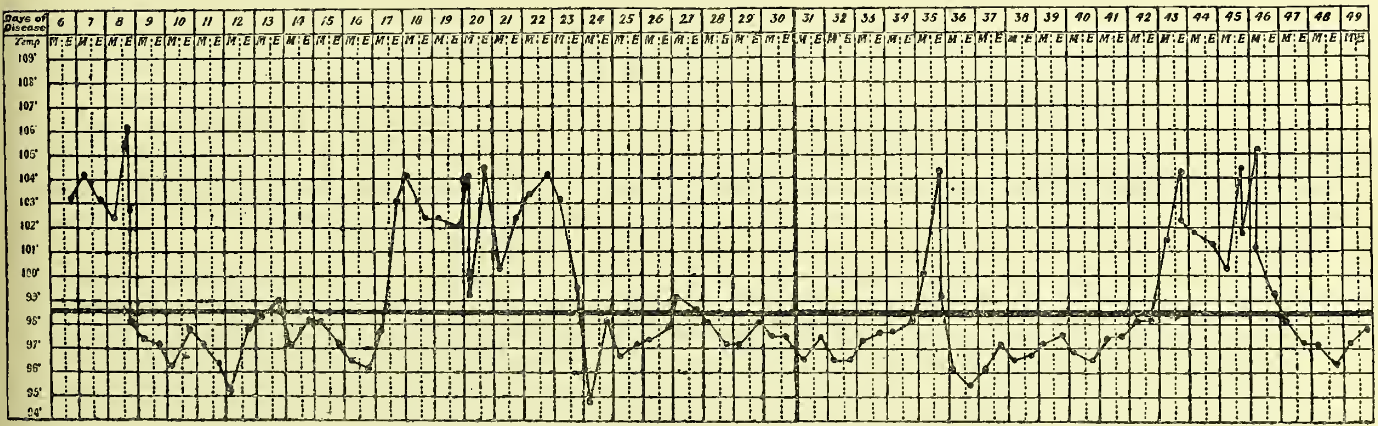

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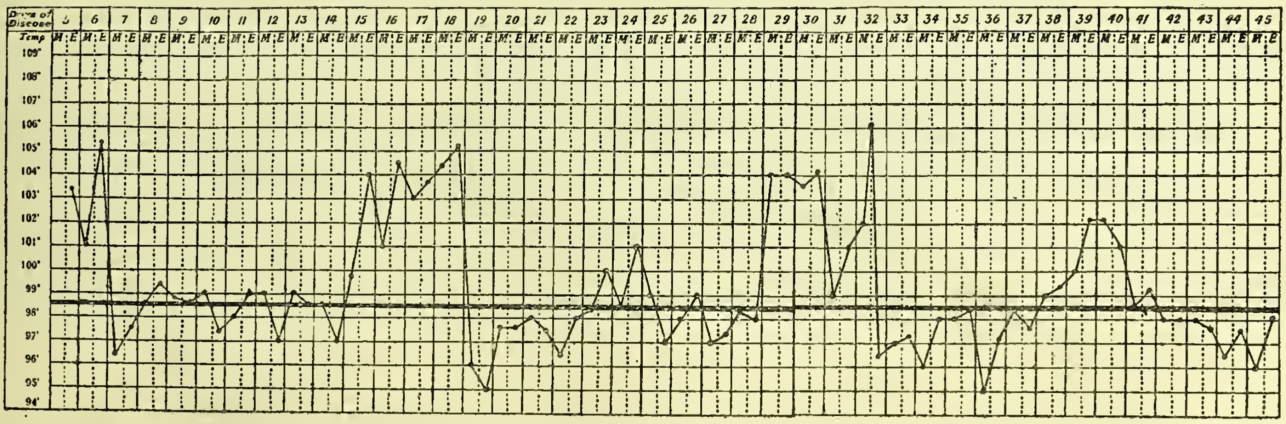

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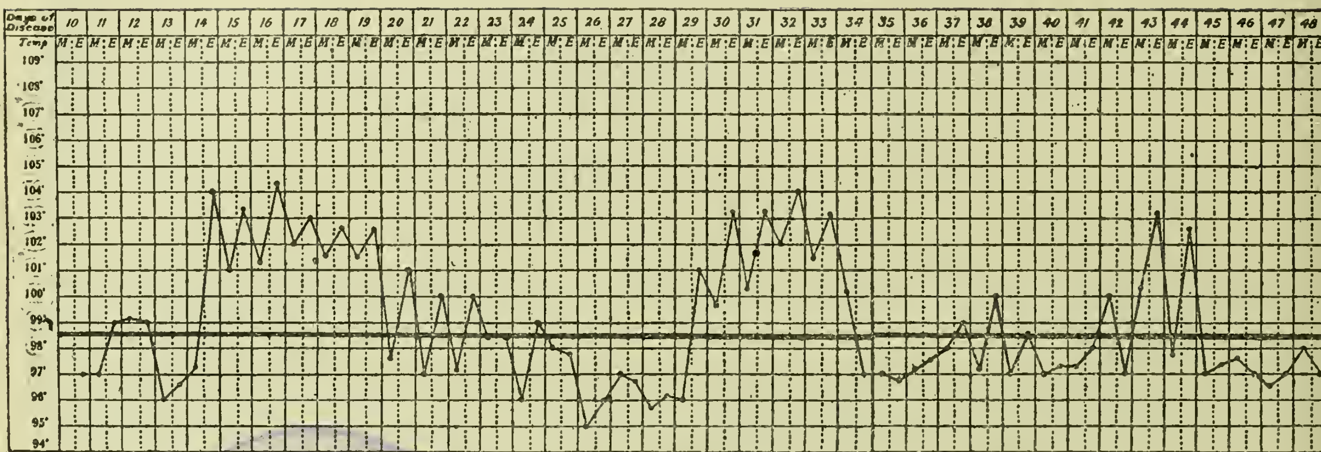

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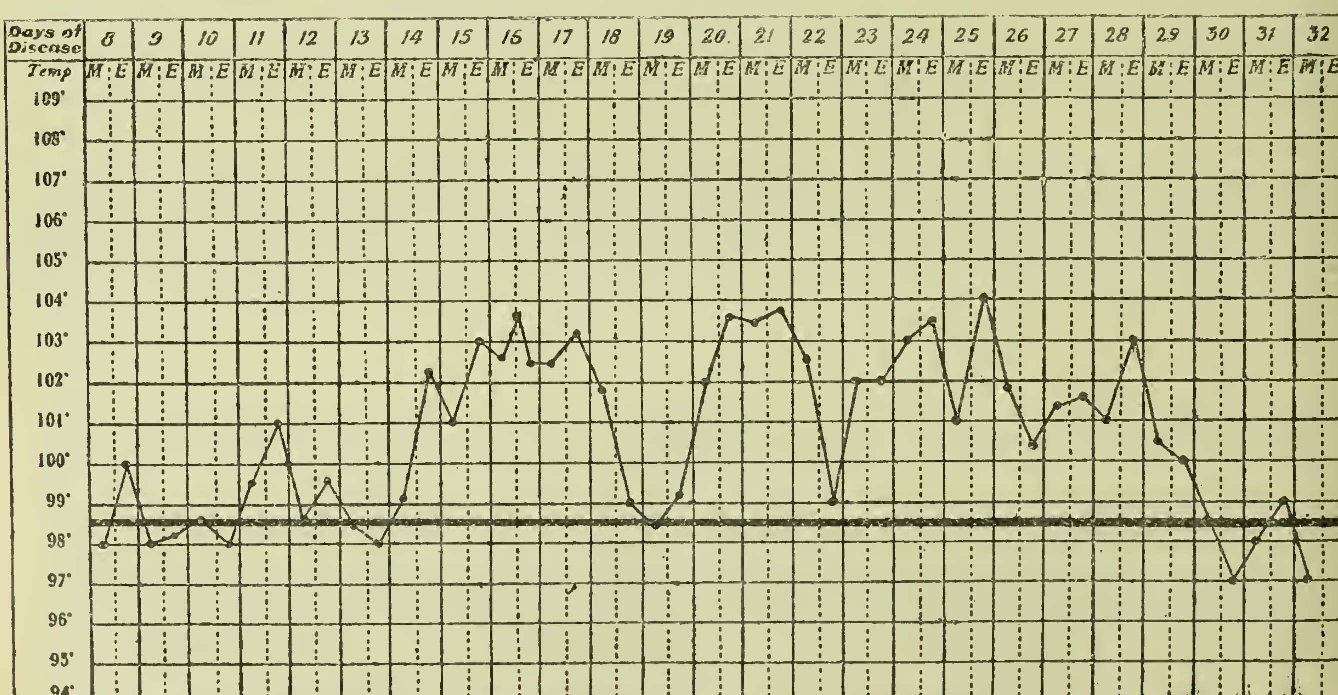

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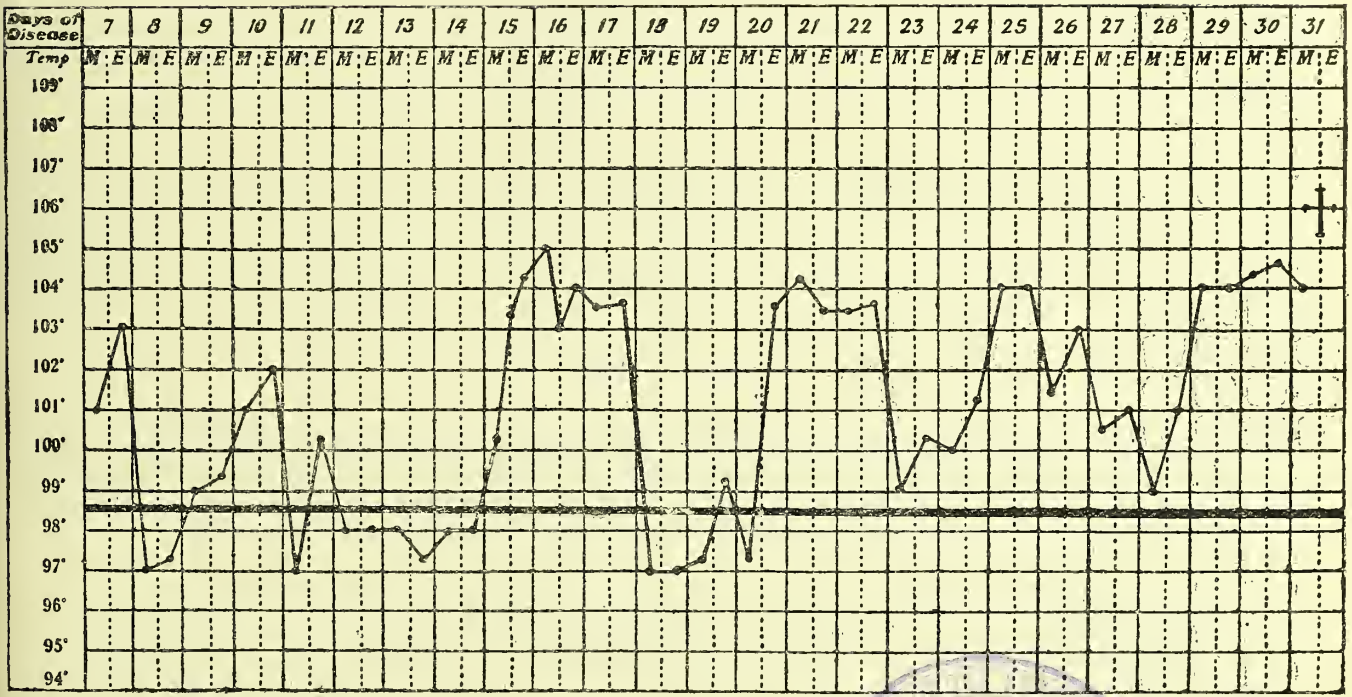

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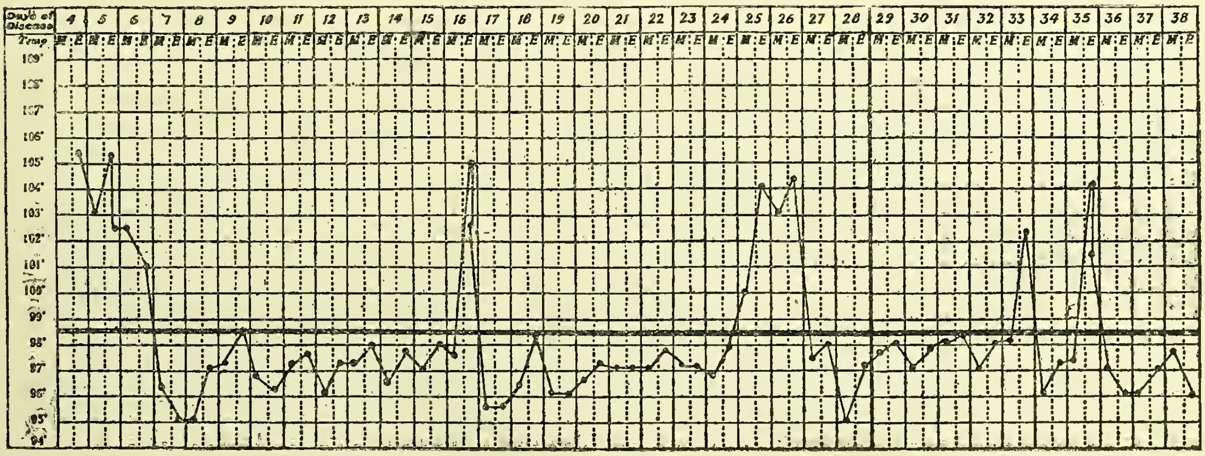

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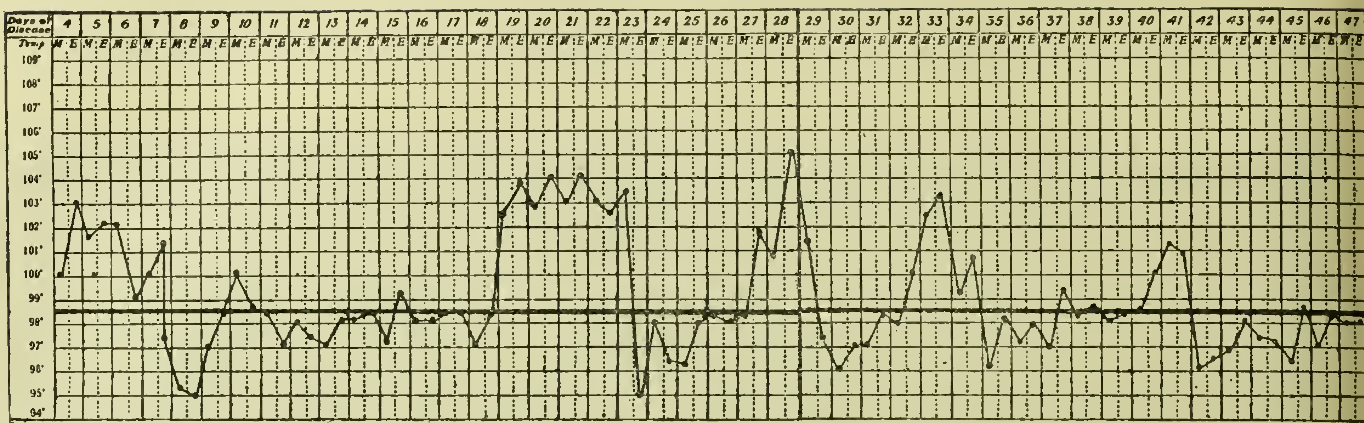

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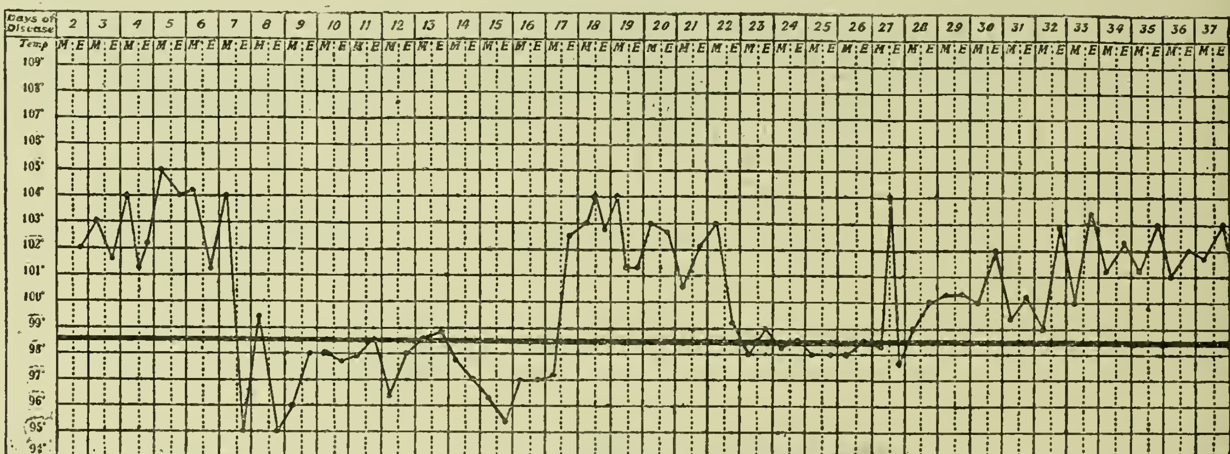

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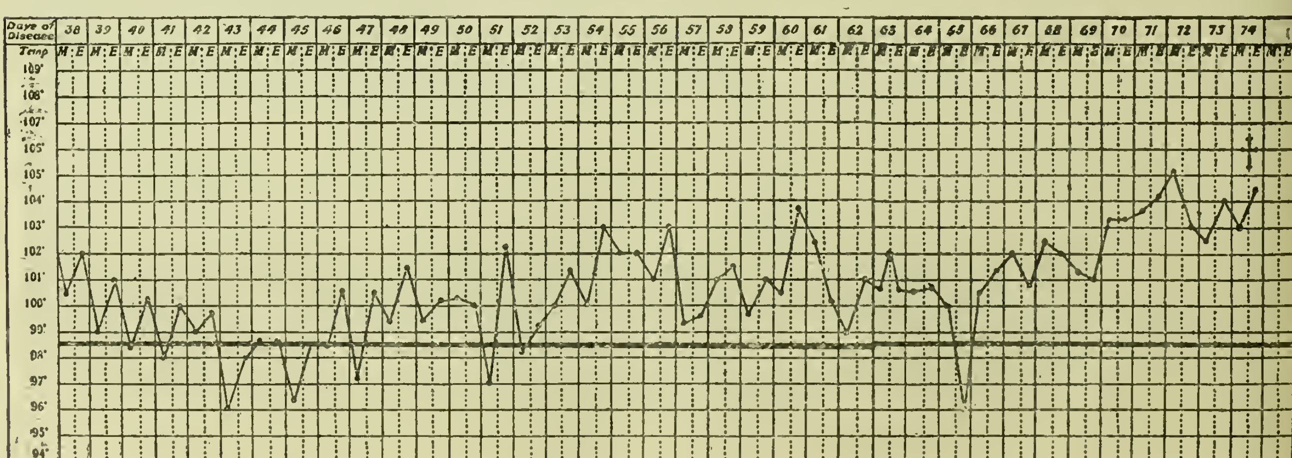

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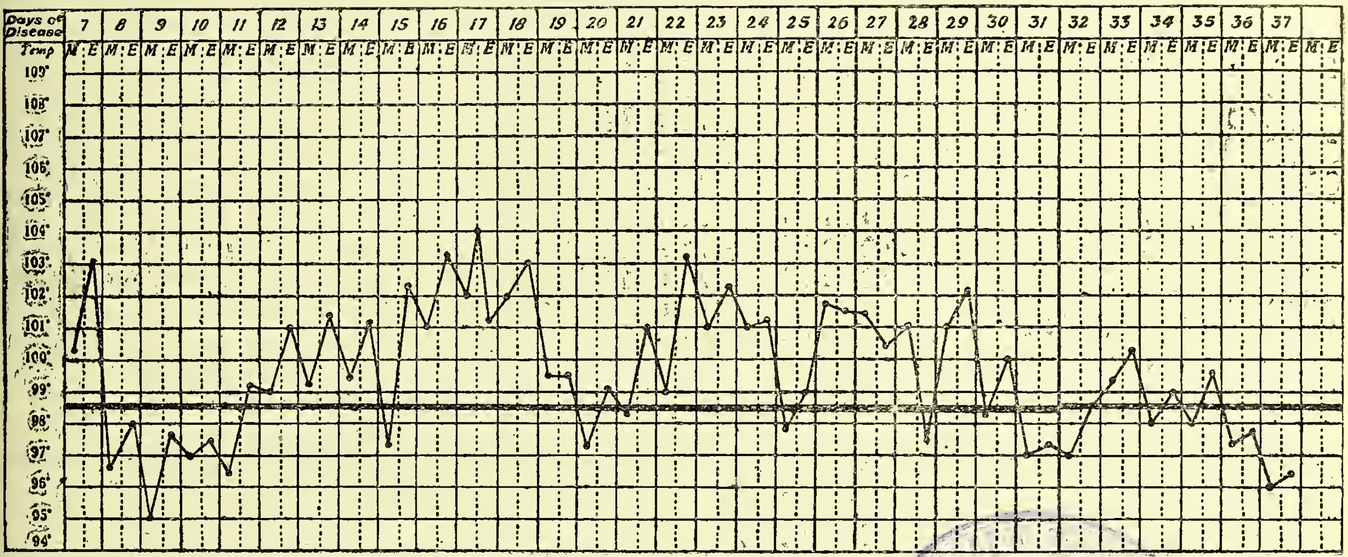

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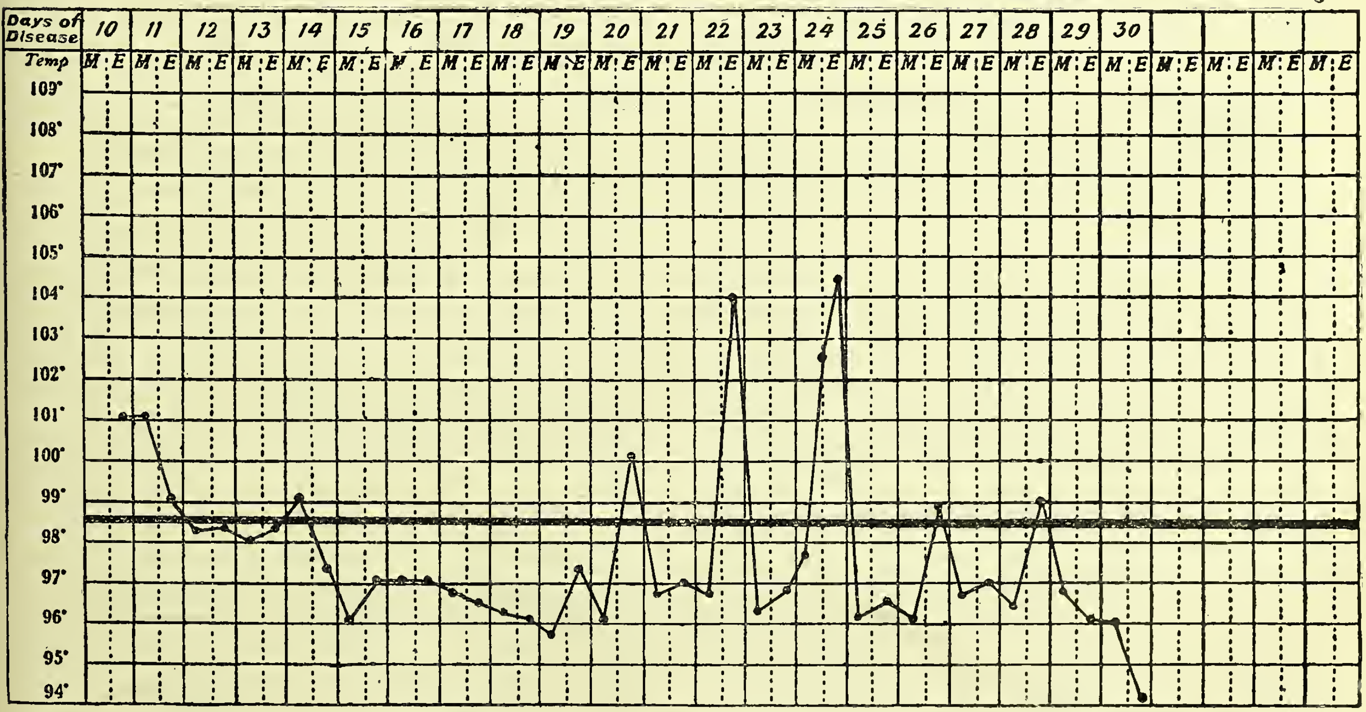

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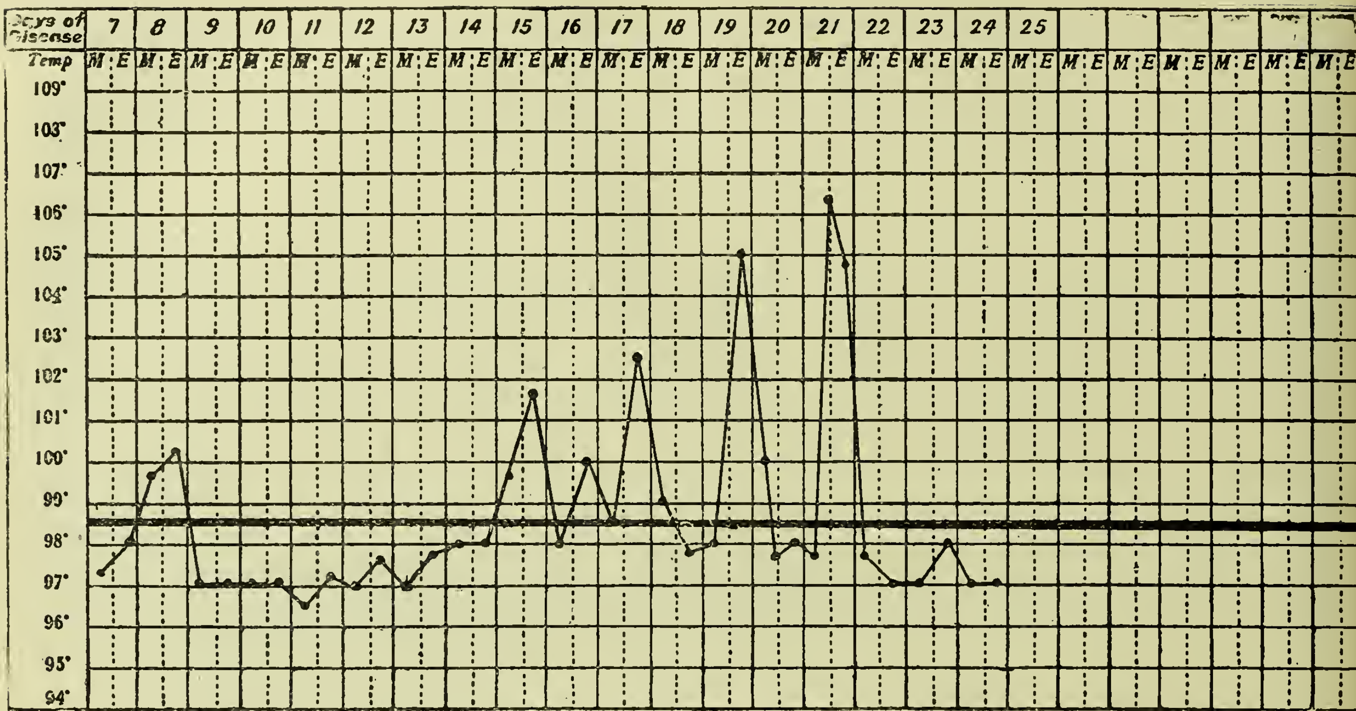

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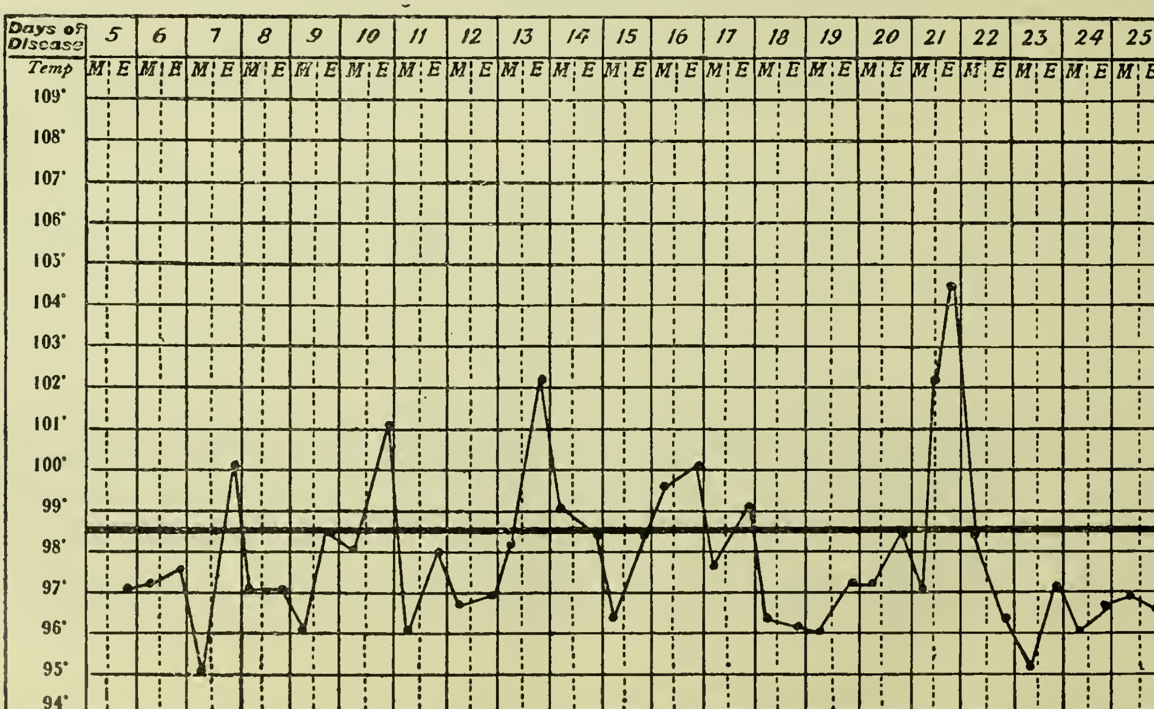

PATHOGENIC SPIROCHÆTOSIS IN MAMMALIA.

By Captain R. M. CARTER, I.M.S.,

Offg. Director, Pasteur Institute of India.

By pathogenic spirochætosis is meant the diseases caused in vertebrates by spiral thread or ribbon-like protozoa. These protozoa form a distinct class closely allied to treponema, trypanosoma, and trypanoplasma, similating parasitic flagellates in the conditions under which they exist and their effects on infection. The investigation of this genus forms a subject of daily increasing importance to the protozoologist, and student of pathology, more especially in the tropics. The majority of spirochætes are direct causal agents in virulent diseases in mammalia and afford a difficult field for research of the highest economic importance to the human and animal races. Many spirochætes resemble each other morphologically, some so much, that a differential biological test is alone of value. This is seen in the differentiation between S. Obermieri and S. Novyi. A study of the structure of the larger varieties, such as are found in the oyster, S. balbiani, and the recently described (Keysselitz) S. anodontæ, in Anodonta cygnea, Fantham, 1907, elucidates the probable structure of the finer and shorter varieties.

An exact knowledge of the morphology of each species is thus at present limited by the limitations of the modern microscope. Deductions drawn from many spirochæta, pathogenic and otherwise, though of the highest interest, do but little beyond help us to understand their shape and methods of progression. The questions of their reproductive cycle, and relationship to Trypanosoma, are fundamental problems at present wrapped in obscurity.

An unstained spirochæte, as ordinarily met with in the peripheral blood of an infected host, *e.g.*, S. Obermieri, S. Duttoni, in stagnant water, S. plicatilis in sputum, S. buccalis, in the floor of some tropical ulcers, Yaws papules, S. pertenuis, etc., is seen under a 1-12 lens, as a transparent filamentous spiral organism, with pointed extremities. It moves rapidly across the field jostling past corpuscles, or cell debris, as the case may be. This movement is resolved into two components, (*a*) vibratory flexion in the line of greatest length, the main means of progression, (*b*) a transverse screw-like translation forward due to the action of the lateral blade-like extension of the ectoplasmic periplast.

This minute ectoplasmic membrane invisible in the finer spirochæta is best seen in stained specimens of S. Balbiani, S. anodontæ, and is found to be made up of fine longitudinally arranged myoneme fibrillæ.

By modifications of Romanowsky's stain, often peculiarly suited to the species of spirochæte under observation, these flexible filiform protozoa, as a class, present the following morphological characters.

(*a*) A linin core, thickly covered with chromatin, which core is of equal thickness throughout the length of the parasite, except at its terminal points. These latter may be pointed, rounded or bulbar according to the particular stage of life history in which the spirochæte has been killed. Further, the relationship between the chromatin and the linin is found to vary occasionally under conditions which will be described later. The linin core is ensheathed in (*b*) a fine cytoplasmal periplast with pointed ends. This periplast presents in certain spirochæta, attached along their line of greatest length, like the blade of a drawn-out screw, a fine undulatory membrane. This is a definite organ of locomotory function. The myonemes of this membrane were partially torn with the periplast from the linin core, in the preparation of stained specimens, somewhat resemble flagella, and have given origin to the erroneous theory that spirochæta are flagellated bacteria.

Spirochæta may present several type shapes.

(*a*) Relatively rigid screw-like spirals with several and similar applications in a definite line or curve.

(*b*) Worm-like highly flexible threads with curves irregular in number, size and direction.

(*c*) Transitional forms.

(*d*) Reproductive forms (*a*) showing simple longitudinal division and (*b*) others of a more complicated nature.

(*e*) Degenerative forms.

I have already indicated the main morphological differences between spirochæta and bacteria. It will now be seen that their biological distinctions are still more definite. Spirochæta produce conditions within their host different to those caused by bacteria in a similar host, periodic or alternating generations invade the peripheral blood stream, and then vanish: such a phenomenon is well seen in S. Obermieri, S. Duttoni, hence the popular term "relapsing fever." A spirochætal swarm will increase to a high point, within the infected host, without causing grave disturbance, they will then react markedly in some varieties to specific drugs. A good example of this is seen in the case of S. gallinarum which vanishes from the peripheral blood on administration of atoxyl. S. Duttoni, whilst unaffected by atoxyl, will succumb to the action of Trypanroth and dyes. Hyperimmune sera cause speedy disintegration and disappearance of their specific spirochæta, such facts differentiate this class of pathogenic parasite from bacteria whose reaction to drugs and antisera is notoriously ineffective or prolonged. These evidences of the protozoal nature of spirochæta are accentuated by the fact that not only are several varieties conveyed

to the vertebrate host by invertebrates, such as O. moubata, Argas persicus, Boophilus decoloratus, but the offspring, born from eggs laid by infected ticks, are capable of reproducing the specific spirochætosis in other clean vertebrate hosts. This parasitic cycle in the tick has been closely investigated in O. moubata and will be subsequently dealt with. As a final proof of the protozoal nature of spirochæta, it has been shown that bacterial media are useless for their cultivation, and multiplication under artificial condition has been recorded alone by the collodion sac intraperitoneal method in animals.

Many of the mammalia carry about with them spirochæte messmates, harmless and otherwise. Some are constant inhabitants, S. dentium in the human mouth. Others are occasional visitors, whose note may be saprozoitic, or parasitic, or lie half way between the two, capable of assuming either when opportunity offers. The modes of infection with pathogenic spirochæta, as a rule, are obscure, but would seem to depend upon whether each variety shows a selection preference for mucous and alimentary tracts, cutaneous surfaces, neoplasmal tissue, or the blood stream.

We find S. dentium, S. buccalis, living a seemingly saprozoite cycle in normal human mouths, similar spirochæta are found in the normal mouths of animals. In cases of Pyorrhœa alveolaris in India, increase of spirochætes is well marked. Cases of tonsillitis, together with buccal ulcers, the latter covered with a tough yellowish white diptheroid membrane composed of felted masses of spirochæta, have been noted in the Soudan. Bousfield 1907.

Enormous spirochætal increase in the buccal cavity is seen in the tropics in some cases of sprue, beri-beri, and dysentery. This condition points to either a specific infection from an outside source, or to a change in the role from saprozoite to that of parasite by one or more species of spirochæta infesting these tracts. It is worth noting as possibly bearing on the question of buccal infection from external sources that spirochæta have been found in water and marine organisms. S. plicatilis have a seemingly metatrophic existence in stagnant water. S. Balbiani (Perrin) infects the crystal style of the oyster, S. anodontæ (Keysselitz) recently described by Fantham 1907 infects the mussel. S. hirudinis has been found in the leech, S. jonesii, in a mud fish (Dutton, Todd, and Tobey, 1907. S. culicis live a parasitic cycle in the larvæ and adult culex (Jaffé 1907). S. polyspira (Wolf, 1907) occurs in decaying potatoes.

If we consider the alimentary tract of vertebrates, we find that normal dogs, cats, rats, mice, and birds, harbour spirochæta, S. Bizozzeri, in their stomachs. It is highly interesting, therefore, bearing in mind the relationship between these protozoa and trypanosoma, to note the pathogenic role assumed by spirochæta in the intestinal ulcers of dogs and monkeys suffering from trypanosomiasis.

S. Eberthi has been noted in Lieberkuhns crypts in the gut of geese, S. danteci in enormous numbers have been found in the dejecta of some cases of severe dysentery in man.

The pathogenic role exhibited by spirochæta when in selective connection with the mucous and alimentary tracts does not seem always confined to their surfaces. It seems they may, in the case of S. Vincenti, cause the grave general condition known as Vincent's angina. Moritz, 1905, has described a general condition of anæmia and carcinomatous lymphangitis, co-existent with extensive spirochætosis, inflammation, and ulceration of the alimentary tract. The bone marrow in such cases shows heavy invasion by spirochæta. Plimmer describes another form of generalized spirochætosis in guinea-pigs where spirochæta are found in numerous pseudo tuberculous lesions.

Focal increase of special spirochæta that have spread from a neighbouring spirochæte infected area is occasionally seen. This is seen in some cases of tuberculous pyelitis in man, S. pyogenes, and human balanitis, Levaditi, 1906. I have seen a similar condition in a case of parotid abcess in the dog. That spirochæta may spread to the respiratory tract would seem probable from the cases of hæmorrhagic bronchitis in man recorded by Castellani, 1906, and pleuropneumonia in horses, Baruchelo and Pricolo, 1906. Whether these parasites are in all the above examples of varied pathological conditions, their direct causal agents remains to be proved. Their presence in such vast numbers is very suspicious.

Spirochæta have been recorded in several ulcerative conditions of the skin in mammalia. Dodd, in 1906, notes they occur in vast numbers in an ulcerating dermatitis in pigs.

I have seen them frequently in Aden ulcer. Prowazek, 1907, records their presence in other tropical ulcers. Castellani, 1907, based on experimental work with monkeys, states that S. pertenuis is the definite causal agent in Framboesia tropica.

Fine spirochæta have been frequently recorded in ulcerating granuloma of the pudendi; S. vaccinia occurs in the vaccine pustules in calves.

In all this group of cases, the spirochæta live symbolically amidst cocci and bacilli and flourish where conditions of ulceration form one of the main pathological features of the disease.

The question of the relationship between spirochæta and neoplasms is one of great interest, and affords a wide field for research. S. pseudopallida have been found in the castration tumours of swine in Western Australia (Cleland, 1908), and in ulcerating surfaces of carcinoma by many observers. They occur in primary and transplanted carcinomata of the breast in mice. In the latter case it would seem more likely that either these protozoa are introduced

with the tissue at the time of experiment, or that such subcutaneous neoplasms afford a suitable pabulum for this class of parasite. The tumour may thus be subsequently invaded from the blood stream by a special spirochæte in the mouse. That this spirochæta should play the role of a causal factor in breast carcinoma is unlikely.

When pathogenic spirochæta are definitely blood selective, such as S. gallinarum S. Duttoni, they may in most instances be transmitted by inoculation. The exact method in many cases is unknown, but recent research has proved that several spirochætal diseases are transmitted in nature by ectoparasites.

It is possible by feeding uninfected birds with blood highly charged with S. Marchouxi, to infect them with this parasite through the alimentary tract. It would not be thus unreasonable to suppose that feeding with infected ectoparasites would have the same result, and that thus certain spirochæta infections may arise. The question of the part played by ticks, in the transmission of pathogenic spirochæta, will however be dealt with later. Of all pathogenic spirochæta, those that invade the blood stream possess the greater pathological interest. It is not proposed to discuss S. pallida, the most important and already well known member, but to deal with those causing relapsing fevers in mammalia. Since Obermier in 1873 discovered that S. recurrentis was the cause of relapsing fever in Europe, many similar parasites have been proved to be the specific cause of similar fevers in vertebrates. Of these, several supposed species in the same or similar hosts have been named after those observers who first noted their occurrence in different parts of the world. Whether each of these will subsequently be shown to be an actual zoological species remains to be proved by future investigation on their life cycles, or the application of biological tests such as that of acquired immunity. The following is the accredited nomenclature of this blood selective group. Such names as have been given serve for our present differentiation of what may in several cases be merely varietal characters acquired by a single species as the result of climatic or other conditions in the vertebrate and invertebrate hosts:—

——	Host.	Name.	Discoverer.
Man	Europe	S recurrentis	Obermeier, 1873.
	India	S Carteri	Vandyke Carter, 1877.
	E. Africa	S Rossi	Ross and Milne, 1904.
	W. Africa	S Duttoni	Dutton and Todd, 1905.
	N. America	S Novyi	Novy and many other workers.
Domestic animals.	Horse	S equi	Theiler and Martin, 1906.
	Sheep	S ovina	Theiler Martoglio, Carpano, '04
	Cattle	S Theileri	Theiler, 1902.
Birds	Goose	S anserina	Sakharoff, 1891.
	Fowl	S Marchouxi	Marchoux & Salimbeni, 1903.
Rodents	Mus decumanus, India	S minor	Vandyke Carter, 1887.
	Nesocia bandicota	Var Lingard	Lingard, 1899.
	Mus decumanus, America	Smuris, Virginiana.	MacNeal, 1907.
	Mus musculus	S muris	Wenyon, 1906.
Bats	Vespertilio kuhli	S vespertilionis	Nicolle and Comte, 1906.

Other spirochæta have been recorded in the blood stream of mammalian hosts in different parts of the world; their position is however uncertain.

Such spirochæta are described by Slutrae Prowazek, 1907. In monkeys (Leishman, 1908), hill cattle, the camel and elephant (Lingard 1907), in man in Arabia (Carter, 1908). Similar parasites been found in Antelopes, Aepyceros melampus, Bu- have been found in Antelopes, Aepyceros melampus, Bubalis Cokei, Gazella Thomsoni (Ross, 1907).

Pathogenic spirochaetosis in bats and rodents will be dealt with briefly as follows:—

In Bats.

S. Vespertilionis was discovered by Nicolle and Comte, 1905, in Vespertilio kuhli et Tunis. This parasite is very finely pointed at both ends, varies in length from 12μ to 18μ in breadth, averages 14μ. It gives rise to a definite relapsing fever in spirochæte free bats on inoculation. Experimental animals present usually but one relapse, with recovery, and subsequent immunity. Transmission experiments with other animals failed. Gonder in 1908 confirms the discovery of this new parasite.

In Rodents.

Vandyke Carter, in 1887, discovered S. Minor in Indian rats. He records that it produces no appreciable pathological effects in these, and he could not transmit the disease to rats or monkeys. Lingard, in 1899, describes a similar spirochæte in Nesocia bandicota which however differs from S. minor, in being pathogenic for guinea-pigs and rabbits, causing death after 24 days.

Wenyon, in 1906, and subsequently Breinl and Kinghorn, in the same year, discovered a minute spirochæta infesting the blood of mice from Paris. It is one of the most minute of the spirochæta. Its length is 2 to 4μ. It has 4 spiral curves, and one extremity is more pointed than the other. This spirochæta on inoculation has an incubation period of about 5 days showing heavy blood infection on the 10th day. Infected mice present the spirochæta in the peripheral blood over 4 months after inoculation. This species of parasite can be transmitted to rats, which present spirochæta peripherally about the 6th day.

A similar parasite was discovered by MacNeal in America 1907 in Mus decumanus, Morgantown Virginia. It would seem to present slight morphological differences from S. muris (Wenyon) being 3'5μ, long with 3½ spiral curves '25μ, broad. At each extremity he also notes a fine flagellum like continuation of the periplast. This spirochæte was easily transmitted by inoculation to wild rats and mice. It is probably the same as S. minor discovered by Carter.

Spirochætosis in Birds.

Spirochæta are highly pathogenic to this class of host, and spirochætosis is one of the commonest causes of fatal epidemics amongst fowls throughout

Northern and Western India. Sakharoff (1891) discovered S. anserina was the cause of the fatal epidemics amongst geese in the Caucasus. The course of the disease is a rapid one and these birds rarely survive inoculation with infected blood. On the 4th to the 10th day after inoculation the parasites appear in the peripheral stream. They rapidly increase until they are found during the febrile period in skeins of hundreds of parasites amongst the corpuscles. The bird wastes, rapidly dies in an emaciated condition, and in a kind of toxæmia, in about 7 days. The peripheral blood before death, presents but few unaltered parasites. Sub-inoculation experiments upon chickens give rise to a transitory non fatal spirochætosis, a good example of the selective pathogenicity of this spirochæte for its particular host.

The parasite closely resembles S. Obermeiri morphologically. S. Marchouxi was first noted in the blood of fowls by Marchoux and Salimbeni in Brazil. Similar fowl spirochætosis has been recorded in India by Greig; it is especially common at Kasauli; I have seen the same disease at Poona, Quetta, Jacobabad and Jhansi in India. Reaney (1907) records its occurrence in Central India. It is common in Egypt and S. Australia, and is probably far more widely distributed throughout the world than is suspected. The course of this disease in fowls is rapid and interesting. Spirochæte free fowls are placed in a fowl pen known to harbour infected Argas persicus, a common ectoparasite in all its stages on the Indian fowl. On the second and third day the fowls show fever 40-43°C and marked and increasing diarrhœa. They stand in the sun with ruffled feathers, and closed eyes. They feed rarely, but drink frequently. Examination of the veins along the inside of the wing, the head, and breast, show hundreds of young ticks in clusters, a small area of subcutaneous hæmorrhage surrounds the imbedded mouth parts of each parasite. Examination of the blood on the evening of the second day shows a scanty peripheral spirochætosis. On the third and fourth days, the majority of the birds will be seen lying about the pen on their sides. They show marked anæmia of the comb and are unable to raise or support their bodies on their legs. On the fifth or sixth day, peripheral spirochætosis disappears, but the fowls still lie in a moribund condition. Definite spasms occur and death frequently is seen during such. On *post-mortem* examination of such early cases, anæmia, general wasting and enormous splenic enlargement are the main pathological conditions. The liver is often swollen, and fatty, showing occasional necrotic foci.

Slow recovery from a cachectic condition, the result of the first generalised spirochætosis, will now be seen in the survivors. A second febrile attack may appear with increased anæmia. In such cases, the diarrhœa reappears, the bird usually refuses all food. Rapid emaciation sets in, until the fowl is reduced to a skeleton of its former self and lies in a choleraic condition. The temperature which after this attack falls rapidly now becomes subnormal, and the fowl almost invariably dies in the second week after infection. *Post-mortem* examination, in addition to the above mentioned conditions, shows atrophy of the spleen and liver with anæmia of other viscera. Fowls are easily infected by feeding or inoculation with S. Marchouxi infected blood. Geese and ducks are highly susceptible to this parasite. Levaditi has obtained a transitory spirochætosis in the rabbit. My similar experiments with this spirochæte failed in three successive cases.

Pigeons on inoculation develop fever without peripheral spirochætosis. Monkeys and guinea-pigs are immune, but doves, sparrows and guinea-fowls are susceptible.

Spirochætosis of domestic animals.

Spirochæta equi was discovered in S. Africa by Theiler in 1904. A similar parasite has been recorded in British East Africa by Stordy, 1906. The animal showed intense wasting transitory œdemata above the orbits and between the legs with a subnormal temperature. The case terminated fatally. Martin, 1906, notes a similar spirochætosis in French Guinea. The parasite presents 3—4 spiral curves, is 12 –15μ long, $\frac{1}{4}\mu$ broad. The infected horse was emaciated and showed paralysis in the hind quarters. Inoculation experiments on other animals failed. The animal recovered, being spirochæte free in $2\frac{1}{2}$ months. This last September I discovered a similar parasite affecting cavalry horses in the 1st Skinners' Horse at Lucknow. The animals had high fever and a second relapse was occasionally seen. Sub-inoculation from infected animals during the onset of the fever into guinea-pigs and rabbits produced high fever with relapses. In rabbits only a scanty peripheral spirochætosis was seen in one case. These animals wasted rapidly during the febrile period. Guinea-pigs showed a rise of temperature for a few days, then remained well. Rabbits inoculated with decline blood showed no symptoms. The rabbit which showed scanty peripheral spirochætosis developed paralysis of the hind quarters, and died in an intensely emaciated condition; a second rabbit inoculated from this animal developed high fever with wasting. There was no peripheral spirochætosis, and the animal slowly regained its normal condition. This occurrence of equine spirochætosis in India is, I believe, the first as yet noted.

Theiler discovered S. Theileri, in the blood of cattle in the Transvaal in 1902.

Koch, 1904, records a similar condition near Dar-es-Salam and in German East Africa; so does Ziemann, 1905, in the Cameroons; Heanley in China. 1906, records a similar spirochætosis in the buffalo. Theiler failed to transmit the parasites to

cattle and ordinary laboratory animals. Many of the infected animals were co-existently infected with piroplasma, but, as peripheral spirochætosis with high fever was noted in piroplasma free animals, the pathogenic nature of this species would seem undoubted. The parasites S. Theileri are actively motile 20—30μ. long. Small forms only 8μ. occur.

S. Ovina was discovered in 1904 by Theiler in the Transvaal; also by Martoglio and Campana in Abyssinia, 1904. Ziemann, 1905, records it in the Cameroons. Here again the Abyssinian spirochætosis was co-existent with piroplasmosis and transmission experiments in sheep failed. I have seen a similar condition in sheep along the Tiban river in S. Arabia. The disease was rapidly fatal with intense emaciation, fluid diarrhœa and an ulcerated condition in the intestines.

Much discussion has arisen amongst those workers interested in this group of spirochæta found in horses, sheep and cattle. Dodd, 1906, claims that S. Theileri, S. equi and S. ovina are identical, and in support of his view shows that he has been able to infect horses, cattle and sheep with the blood of spontaneously infected horses. Up to date no biological proof has been offered that an acquired immunity to any one of the three will protect against inoculation with one of the other two and the question of their identity is still a matter of doubt.

Human spirochætosis.

Several blood selective spirochæta with distinctive names have been recorded as infecting man in Europe, India, Africa and America. It has been definitely proved that S. Duttoni is a different species from S. recurrentis by Breinl. The question of the relationship between S. Duttoni and S. Rossii, and the differentiation between S. recurrentis, S. Carteri and S. Norvi still remains, I consider uncertain. It is, however, advisable to consider for the present each under its present distinctive name as an accepted species. A discussion on human relapsing fevers would here be unnecessary as they form a subject which will be specially dealt with in full by other contributors at this Congress. It is, however, proposed to consider how certain mammalia are infected with spirochæta, concluding with a few remarks on the life cycle of these parasites, and our present knowledge of immunity in spirochætal diseases.

Transmission of Spirochæta by Arthropod Hosts.

In nature the transmission of certain spirochæta from host takes place by the agency of ectoparasites. Most of these as yet discovered are arthropod hosts. Fowls under ordinary conditions are infected by the bites of Argas persicus, especially in the early stages. Though this tick is usually responsible for the disease, it has been shown experimentally that other ticks such as Argas reflexus and Ornithodorus moubata fed on infected birds have been able to transmit the disease. S. Theileri is transmitted by Boophilus decoloratus. Human relapsing fever in Africa by O. moubata. Another variety of ornithodorous, O. turicata, is said to be responsible for the transmission of relapsing fever at Bogota in Colombia, Blanchard, 1907. Infection usually takes place by the bite of these ticks when the host is sleeping. The bite of Argas persicus and Ornithodorus Tholozanni is similarly dreaded in Persia. The severe febrile conditions following the bite of the "Miana bug," as these are locally named, is well known amongst travellers in these parts. Relapsing fever in bats is said to be probably transmitted by Argas vespertilionis=Caris vespertilionis.

The infectivity of ticks is a matter of economic importance. It will be seen that this sometimes depends upon the temperature at which they happen to be living as well the stage in which they attack their hosts. Recently research work by Borrel and Marchoux have shown that ticks, fed on infected fowls and then kept at 15—20°C, will not infect non-immune fowls after being kept four days at this low temperature. The ingested spirochæta seemingly vanish from the gut content and tissues of the tick.

These infected ticks if kept for three months at this low temperature will never infect though fed repeatedly. On subsequently placing the same insects in an incubator at 35°C., S. Marchouxi reappear in the parasite, and non-immune fowls are at once infected by their bite. From the above experiments, together with the fact that infected ticks will live and remain infective for over six months, we presume that the spirochæta is capable of passing through a definite but as yet unrecognised cycle within the tissues of the tick. This cycle is self-protective, parasitic and non-pathogenic to the invertebrate host but returns to the infective stage of the spiral protozoal organism, ere it, through the agency of the tick, can invade the warm blooded host.

S. Duttoni, the causal agent of relapsing fever in W. Africa, is transmitted to man by the agency of Ornithodorous moubata, a tick common along the main caravan routes in Africa. 5 to 50 per cent. of these ticks examined by various observers have been found infected with these protozoa.

This species of tick will live for two years at least, and is of especial epidemiological interest by reason of the fact that, once infected, a tick will by feeding infect a succession of animals. If infected O. moubata are successively fed on suitable spirochæta free hosts, infection has been conveyed up to the sixth clean animal of the series. Further the tick after each feed lays a batch of spirochæte infected eggs. The progeny born from each of these batches will infect successive clean hosts up to the seventh of the series. On arriving at the egg laying stage, females from this brood will lay successive batches of infected eggs from which, once more, a progeny of spirochæte infected ticks is

born. These are capable of transmitting the disease to spirochæte free monkeys.

Here again we have valuable evidence indicating a special life cycle of spirochæta in the ectoparasite. Based on the microscopic examination of spirochæte infected ova in O. moubata, I recently, 1907, described certain forms assumed by these protozoa which I consider possible stages in their reproductive cycle, and which may be found to occur with greater frequency within the tissues of the infected tick. Certain chromatin staining bodies which I noted, but as yet have not described, within cell elements of infected eggs, laid by the progeny born from infected parents, may possibly be of a similar nature.

The relationship between cattle spirochætosis S. Theileri and Boophilus decoloratus has been experimentally proved. A temporary spirochætosis has been reproduced in European cattle by infected ticks brought from S. Africa. Observers were unable to find the specific spirillar parasite in the tick larvæ, but it is interesting to note in experimentally infected animals that disappearance of the spirochætosis was followed by appearance of piroplasmosis. Both protozoal parasites were, therefore, simultaneously conveyed by the same ectoparasite.

It is as well, ere closing this discussion on the transmission of spirochæta by arthropod hosts, to review other and suspected methods of spirochætal infection.

Several parasites have been popularly accredited with the spread of European and Asian relapsing fevers in man, and much research work with the common bug, Acanthia lectularia, the louse, Pediculus corporis, and certain mosquitoes such as Stegomyia fasciata has been done. The only positive results that bear any serious importance are as follows. Acanthia lectularia were fed on patients with relapsing fever by Tictin, 1897. On crushing these infected parasites he was able to infect himself through small skin lesions. He further infected monkeys by injecting them with the gut contents of infected bugs, but found that these ectoparasites within 48 hours were free of spirochæta and he was unable to transmit the disease. In a way these experiments merely bear out Vandyke Carter's original observation, namely that he infected himself with relapsing fever in Bombay through a some small skin lesion during the *post-mortem* examination of an infected patient. Tictin could evidently only transmit the disease as long as the blood in the gut content of the bug contained undestroyed parasites. Karlinski's experiments in 1902, however, differ markedly in their results from those of Tictin, in that he found motile spirochæta within infected Acanthia lectularia for some 30 days. On later examination these spirochæta showed non-motility and degenerative changes.

Christy, 1902, was unable to infect himself by the bites of infected bugs. I watched similar negative experiments by Todd Breinl and Kinghorn, 1906, with S. Duttoni infected Culex lectularius, on monkeys, and consider these failed due to the fact that these ectoparasites were kept at too high a temperature.

Nuttall, by keeping infected bugs at 12°C, obtained living motile spirochæta in the gut contents for 6 days. By raising the temperature the digestion of the gut contents in the infected bug was facilitated and the spirochæta vanished. A unique experiment has been recorded by the same observer, in that he infected a clean mouse from an infected mouse with S. recurrentis by the bites of 35 bugs. Another striking observation is that by Mackie, 1907, working with Pediculus corporis from infected patients which throws grave suspicion on the body louse as a possible transmitter of Indian relapsing fever. The passage of spirochæta from mother to fœtus has been shown in the case of S. Duttoni by Breinl and Kinghorn, 1906. Levaditi, 1906, by infecting eggs of fowls with spirochæta, produced a macerated condition of the fœtus analogous in many ways to fœtal syphilides.

All pathogenic blood-inhabiting spirochæta, present a common characteristic. They increase in numbers in the blood stream for a time without any seeming pathological effect. Then, when multiplication has reached a certain point, the host exhibits a febrile attack. During this the parasites almost entirely disappear from the peripheral blood. There may be one or more febrile attacks due to periodic multiplication of survivors from a previous parasitic swarm. Finally, unless fatal, the host becomes immune. Levaditi, Neufeld, and Prowazek, 1907, have proved, that in fowls surviving spirochætosis the serum shows agglutinating and spirochæticidal properties upon the living parasite. This condition is due to the action of a complement and specific amboceptor. Further they note S. Marchouxi killed by taurocholate of soda will protect on vaccination.

An interesting feature in spirochætosis is the fact that the immunizing serum derived from the host, during the almost complete protective destruction of one spirochætal swarm, and drawn in the afebrile interval, has, during the first few afebrile periods, no spirochæticidal effect on the more resistant survivors. Recovery only takes place when the blood has protective substances in it sufficiently capable of destroying the most virulent forms of that specific species. Such immunity may last for months. Repeated experimental inoculation of the recovered host, with the specific spirochæte, results in a hyper-immunization of the blood. Such blood is protective and curative. A small dose of this hyper-immune serum will eliminate all parasites from an infected host in an exceedingly brief period.

Marchoux, in 1907, shows that repeated passage of pathogenic spirochæta through the same type

of host, without the intervention of the specific invertebrate host, results in attenuation of virulence, and finally this type of host cannot be infected. On transfering the highly weakened strain of spirochæta into the special invertebrate host, the virulence is at once raised. These striking experiments were worked out on fowls and Argas miniatus. He further notes that infected Argas miniatus kept at 28-29° will infect fowls for an indefinite length of time, probably during the remaining life span of the tick. The effects of certain drugs already mentioned, together with the striking results of hyper-immune sera, augur well for those research workers whose aim is to provide mammalia with a certain and rapid cure for their peculiar pathogenic spirochætosis.

Cytology of Life Cycle.

Spirochæta, like Trypanosoma, are specific, and, related groups of protozoal organisms, both of which present similar difficulties to those interested in the morphology of their life cycle. I propose to discuss the cyclical metamorphosis of Trypanosoma briefly, and show that somewhat similar morphological changes have been noted in the allied spirochæta, in spite of our present ignorance and confusion concerning the life cycle of this group.

Trypanosoma may from the cytological point of view be divided into two classes.

(1) Contact Trypanosoma whose life cycle is not normally complicated by passage through an intermediate host, and whose life history is completed within a single host. For example T. Equiperdum, the trypanosome transmitted by coitus.

(2) Trypanosoma transferred by intermediate hosts, as T. Lewisi, T. gambiense.

Similarly, spirochæta may be divided into

(1) Contact spirochætæ, S. Pallida, S. Balbiani.

(2) Spirochætæ transferred by intermediate hosts, S. Duttoni, S. Marchouxi.

During the developmental cycle of host-transferred Trypanosoma in the blood of an infected host, we find

(1) Alternating phases of presence and absence of the parasites in the peripheral circulation with

(2) An intermediate maximum point of increase in numbers.

(*a*) The phase of increase within the blood stream, a progressive multiplication, is produced by longitudinal fission. We find in this process amitotic division of the nucleus and also of the extra and intra-nuclear centrosomes; development of a new flagellum, and subsequent fission of the parent trypanosome into daughter cells. Each daughter is provided with the full complement of cell elements-nucleus flagellum and extra and intra-nuclear centrosomes.

(*b*) The maximum point of increase in the peripheral circulation. At this point longitudinal division ceases and a new set of morphological changes appear in the parasites.

(1) The extra-nuclear centrosome develops a deep staining band which progressively extends towards the nucleus to which it becomes connected.

(2) This band then disappears, suggesting a temporary interchange of elements between nucleus and extra-nuclear centrosome. What happens later in such trypanosoma is obscure. Possibly a cycle of longitudinal divisions may take place.

(*c*) The phase of decrease in the numbers of parasites in the peripheral blood stream. During this phase the trypanosoma present a rapid series of morphological changes differing from those previously described.

(1) Vesicles appear in the parasite in relation with the nucleus which become more compact. These both then separate from the outer portion of the cell and are enclosed in a fine cytoplasmal layer, thus forming the future "latent body."

(2) The latent body separates from the rest of the cell which disintegrates and sets free the latent body in the blood stream.

(3) The latent bodies are arrested in the bone marrow, spleen, etc.

(4) These latent bodies then increase in size and develop by division of the intra-nuclear centrosome. The new extra-nuclear centrosome becomes flagellated and finally reverts to the stage of typical trypanosoma. They then leave their resting place and stream into the blood during the phase of increase in the peripheral circulation.

In the development of host-transferred spirochæta, such as S. Duttoni, some of the stages are similar to those noted in trypanosoma.

In O. Moubata eggs infected with S. Duttoni evidence of increase by longitudinal division has been shown by Carter, 1907. Other observers have also noted that, after a short period, the typical spirillar form of the parasite can no longer be found in an infected batch of eggs. From this we know that the spirillar type assumes a form hitherto unrecognised. Minute bodies within infected eggs, which I have noted but not yet described, may be this unrecognised form, but more opportunities for observation are required ere a decision can be arrived at. The process of longitudinal division in S. Duttoni similates that noted in the contact spirochæte S. Balbiani by Perrin, 1905, but differs from it in being a process not affecting simultaneously the whole length of the parent parasite. I propose to describe it very briefly as a fuller description of the similar process in S. Balbiani is to follow. It must be borne in mind we are dealing with a spiral cell of extremely filiform thickness. This renders the interpretation and recognition of finer cytological details difficult. The following are the stages noted in S. Duttoni.

1. The stage of subdivision of the chromasome stains deeper than that of the normal spirochæte, a condition comparable to the condensation of the filiform nucleus noted in S. Balbiani.

2. The linin core breaks up into similar segments.

3. The segments become dumb-bell shaped and finally subdivided into chromasome like oval bodies. This stage is again like that noted in S. Balbiani; a difference, however, exists in the presence of a single non-oval staining mass at each end of the parasite.

4. The stage of subdivision of the chromasome, like bodies in a plane containing the long axis of the spirochæte, has not been noted, but must occur, for we find the next phase.

5. The stage of longitudinal division of the parent spirochæte, commencing at one end of the parasite. This stage differs from that noted in S. Balbiani in the fact that one end of the parent parasite presents the chromatin and linin segments in the various stages that precede the final stages of formation of daughter parasites seen at the other end of the parasite.

However, it is evident from this that multiplication by longitudinal division takes place in the spirochætæ as well as trypanosoma during the phase of increase in the numbers of the parasite.

Eggs of O. moubata infected with S. Dutoni, we know, after a time present no longer the spirillar type, though they are still infected. We thus know there is a phase of decrease, and in such eggs we find morphological changes in the spirochætæ, simulating those noted in the trypanosoma during the phase of decrease.

1. The formation of a cytoplasmal capsule.

2. The later appearance within this of a compact nuclear-like mass and vesicle within this capsule of cytoplasm.

Such a body similates cytologically the latent body assumed by the trypanosome above described.

The presence of free oval bodies consisting of a cytoplasmal vesicle with two staining masses of what seem like nuclear matter arranged bipolary is highly suggestive of the freed latent body in its most minute form; this is, however, pure conjecture.

Now to compare the cytology of the life cycle of contact trypanosoma such as T. equiperdum with contact spirochæta such as S. Balbiani. Contact trypanosoma such as T. equiperdum present the following cyclical metamorphosis.

Phase of multiplication, by rapid longitudinal division with amitotic division of the nucleus intra and extra-nuclear centrosome as above described. Then comes a stage in which we note that from the nucleus a mass is budded off the side opposite to that of the extra-nuclear centrosome, which mass passes towards the free end of the flagellum. Whether this is connected with the formation of trophic granules is uncertain. Following the above phase, another stage occurs amongst some of the peripheral parasites. The extra-nuclear centrosome increases in size, and ere long a bud from the extra-nuclear centrosome appears. This passes away from the parent mass towards the nucleus, remaining, however, still connected by a fine protoplasmic thread to the extra-nuclear centrosome. The intra-nuclear centrosome moves across the nucleus towards the approaching nuclear centrosomic bud. The latter then detaches itself completely from its parent mass, and, passing towards the nucleus, becomes seemingly fused with it or its intra-nuclear centrosome. Several buds from the extra-nuclear centrosome may be thus detached and fuse with the nucleus. This process of translocation of portions of the extra-nuclear centrosome has nothing to do with the subsequent division of the parasite as this may take place before or after their fusion with the nucleus. After this process has been completed the parasite shortens and the extra-nuclear centrosome becomes related to an elongated neck of cytoplasm, the remainder of the body of the parasite being rounded up. The extra-nuclear centrosome divides, and one portion or bud passes down the cytoplasmal neck into the central round vesicular body.

Finally, the extra-nuclear centrosome enclosed in a portion of protoplasm is shed from the central mass, which mass then consists of an oval or round capsule of cytoplasm containing a nucleus intra-nuclear centrosome and extra-nuclear bud.

The changes that take place in the round parasite or latent body are best seen in rats infected with dourine just before death, and are as follows:—The new extra-nuclear centrosome divides, and two extremely long flagella are produced from them.

The latter series of phenomena seem to constitute a sexual stage in the trypanosome under consideration, and as such throws light on similar changes noted in contact spirochætæ, such as S. Balbiani. Whilst discussing the morphological changes noted in a contact spirochæta, S. Balbiani, its multiplication by longitudinal division and sexual stage, it must be borne in mind that the ordinary laboratory technique employed by previous observers on S. Balbiani is not that of the cytologist. Until suitable cytological methods are employed we must consider much of this work done on this parasite as lacking those finer cytological details on which a true conception of the life cycle can be founded. What has been shown up to date is as follows:—

Longitudinal division of S. Balbiani.—The nuclear core of the spirochæte becomes spiral with chromatin nodes arranged at intervals upon it. It then condenses into a deep staining rod and segments, the segments becoming dumb-bell shaped. Each of the dumb-bells divides into a pair of equal oval chromasome-like bodies. These then subdivide in the plane containing the long axis of the parasite, resulting in a double and longitudinal row of chromasomes.

A longitudinal split takes place down the centre of this double row, resulting in an equal division of the chromasomes and the formation of the

daughter spirochætæ. These are attached to each other at one end. Reconstitution in a reverse order of the nuclear constituents leaves two mature and perfect spirochætæ, which finally break apart. This process is the normal method of multiplication by longitudinal division and is seen to occur within the gut and crystal style of the oyster. When the style becomes packed with the parasites thus produced, *i.e.*, a period of maximum increase, a second series of morphological changes takes place resulting in the formation of so called gametes. (Perrin, 1905.)

Stages similar to those of longitudinal division take place up to the formation of the dumb-bell stage. These now, instead of subdividing transversely, subdivide longitudinally, resulting in a double row of dumb-bell shaped segments.

Each of these then divides transversely and the result is a double row of chromasomes.

Two capsules of cytoplasm then appear about the centre of the parasite one on each side of it.

Half the chromasome-like bodies from each row pass into its corresponding capsule.

The parasite then splits from one end longitudinally with the result that two daughter parasites are formed, each consisting of a central cytoplasmal capsule with two spirochætal terminals. This is the so-called gamete formation (sexual). It will be seen that this stage in a contact spirochæte is very similar to the final sexual stage noted in a contact trypanosome.

Now to return to the cycle of a spirochæte transmitted by an intermediate host described by Carter, 1908. It will be seen that certain forms have been noted which resemble those found in host-transferred trypanosomata and host-transferred spirochæta.

The following spirochæta, A1, A2, A3, A4, A5, A6, A7, present concentration of nucleus about the centre of the parasite, the nucleus presents an intranuclear centrosome, both enclosed in a kind of capsule of cytoplasm.

B1.—A similar spirochæte, but presenting a second body, possibly the extra-nuclear centrosome. This is seen in a spirochætal terminal.

B2, B3.—Similar spirochæta which indicates that the extra-nuclear centrosome has passed towards the nucleus and seems to be exchanging elements with it.

C. C1.—Spirochæta presenting a capsule of cytoplasm about their centre. This contains a large oval mass, the nucleus and intra-nuclear centrosome. Two bodies lie one each side of the nucleus. These are possibly bodies the result of subdivision of the extra-nuclear centrosome as has been shown in trypanosoma. Evidence of this process is shown in C2. Further subdivision of these bodies is shown in F1, F2.

These features correspond to the changes seen in trypanosoma about the period of maximum increase.

The following spirochæta, F2, G1, G2, G3, G4, G5, G6, show morphological details similar to those seen in trypanosoma during the phase of decrease.

Vesicles appear within the capsule of cytoplasm in relation with a compact nucleus and the extra centrosomic bodies.

From the cytological resemblance of these vesicles to the latent bodies of trypanosoma I am inclined to hold the view that these are also latent bodies in spirochæta.

They may possibly be gametes, and the spirochæta figured Nos. 16, 32, 35 present an appearance of conjugation or interchange of elements which is highly suggestive.

The spirochæta presented in figures 9, 19, 22, 24 also resemble a similar stage noted in trypanosoma gambiense. This encystation stage presents many similar cytological details, and these, as in trypanosoma, are larger than the latent body stage.

From the above remarks it will be seen that this group of parasites is one of the most important engaging the attention of modern workers. In spite of this but little is yet known of their life histories. Until one of these is solved and afford a clue by which to unravel the problems affecting the rest, progress in this branch of protozoology must necessarily be retarded.

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DISCUSSION.

Capt. White said :—In November 1908 I found a spirochæte answering to the description of S. Vespertilionis in the heart's blood of a bat in Belgaum. The bat fell from the roof of a verandah in broad daylight and was in a dying condition. Examination of blood films revealed the presence of the spirochæte in very large numbers. I believe this to be the only recorded instance of the occurrence of this spirochæte in India, and consequently the observation is of some interest.

OBSERVATIONS ON THE DEVELOPMENT OF FLAGELLATED ORGANISMS FROM THE PARASITE OF "ORIENTAL SORE."

Preliminary Communication.

By R. ROW, M.D. (LOND.), D.SC. (LOND.).

From F. D. Petit Laboratory, Byculla, Bombay.

The parasites which form the subject of this paper were derived from the lesions found in a disease which has been endemic in Cambay for several years and which goes by the local name " Ashrafi " (Ashraf = a gold coin of the Mogul times—a word therefore indicating both the characters of the sore and the possible source of its importation through Moguls from Delhi). The disease is what is generally recognised as " Oriental Sore " or Delhi boil. The clinical characters of the disease as it occurs in Cambay differ in no essential respect from those found in the description on " Oriental Sore " in any modern textbook on Medicine, and therefore call for no particular notice here beyond one or two points or alleged traditions generally accepted as facts of importance by the inhabitants of Cambay. The disease is restricted to this place, a coast town a little north of Broach, and there is

nothing special either geographical or climatic to characterise the place as a spot specially suited as a seat of election. The water supply however seems to be different to that of the neighbouring towns and villages. The drinking water is the rain water of the monsoon stored up in tanks or small reservoirs as the well water is exceedingly brackish owing to the extreme proximity of the sea and the silted shore. The popular belief is that the disease is caused by the drinking water, but there are no known facts to support this belief. Thus the disease may affect only one or two members of the family while others may escape. It is believed that all new comers and fresh arrivals are "bound to suffer from the disease" provided they stay there long enough (for one or two years) and the belief is so well established that the disease is styled "Kambathno Shikko"—the seal of Cambay impressed on individuals for their having eaten the salt and drunk the water of Cambay. The disease commonly attacks children but older people are not exempt provided they had not the disease in the earlier part of their life. There is no social or racial predisposition for the disease, as people in good circumstances of life and officers both European and Indian who may have to spend some years of their life in the place are attacked. One attack confers immunity for life, although during one attack more than one "Ashrafi" may make its appearance on the same person. The author has seen scars of over 20 such Ashrafis on the body of a young student who was kind enough to show him these scars and he had the disease when he was about 12 years of age. It is a popular belief that until a person goes through the fire of Ashrafi he always keeps delicate and weakly and that his health improves remarkably after an attack, and, with this reservation, the inhabitants of Cambay claim their town, with a certain amount of local patriotism and pride, to be a healthy place, almost a sanatorium.

Historical Resumé.

The parasites found in the "Oriental Sore" of Cambay show no special character in addition to what is already known of them ever since their presence was pointed out and fully described by Cunningham in a paper in the "Scientific Memoirs" of 1885.[1] The observations of this worker are so interesting that it seems a matter for surprise that no further advance on the subject should have been made for nearly 20 years, until Wright's (of Boston) researches on the parasites, as he observed them both in the large mononuclear macrophages as well as outside these cells found in the scrapings from the "Oriental Sore," attracted the attention of workers and brought the knowledge of the subject within the scope of modern methods of research and observation.[2] A further study of Delhi sore by James [3] confirmed these observations and have contributed to establish the identity of the parasites found in a variety of oriental sores going by different names, *e.g.*, Delhi sore, Lahore sore, Sindh sore, Frontier sore, &c., according to the places where they are found endemic (and I might add to their number "Ashrafi" or Cambay sore), and, further, James' observations have helped to confirm the morphological similarity almost amounting to identity of the parasites of the oriental sore with the parasites of Kala Azar "as the parasites," to quote James' own words, "cannot be distinguished by examination under the microscope from those obtained from the spleen and other organs in certain cases of splenomegaly and Kala Azar".[4] The similarity between the parasites of oriental sore and those of Kala Azar is so striking that Manson[5] has been tempted to call the two morphologically and specifically identical, and suggest that the parasite of the oriental sores may bear to that of Kala Azar the same relation as vaccinia does to variola. Although thus undistinguishable from each other the two parasites were suspected to be at least specifically different from the consideration that the two diseases occur in quite different localities, *i.e.*, where Kala Azar is most prevalent Delhi sore is conspicuous by its absence and *vice versa*.[6] The important work by Leishman,[7] Rogers,[6a] Ross,[13] Donovan[8] and others who have contributed to our knowledge in recent years of the characters of the parasite of Kala Azar (Leishman-Donovan body) has not, unfortunately, helped to establish any specific differences between the parasites so similar in appearance even from a developmental point of view, notwithstanding the remarkable discovery of Rogers [9] (who demonstrated the various developmental stages of the Kala Azar parasites up to a herpatomonas like flagellate) and subsequent confirmation of the same independently by Dr. Chaterji[10] working in Rogers' Laboratory and Capt. Christopher's working in Madras.[11]

The controversy which raged round the Leishman-Donovan body as to its exact zoological position had also its influence on the decision as to the position to which the parasite of the oriental sore was to be relegated. But, owing to want of definite data beyond the similarity of the two parasites and the dissimilarity of the diseases produced by them, the parasite of the oriental sore has

[1] D. D. Cunningham: Parasitic organisms in the tissue of Delhi Boil: Scientific Memoirs by Medical Officers of the Army of India, 1885.

[2] J. H. Wright: Protozoa in a case of Tropical Ulcer: Journal of Medical Research, Dec. 1903, Vol. X 3.

[3] S. P. James: Oriental or Delhi Sore: Scientific Memoirs, India, New Series, No. 13.

[4] S. P. James: Ibidem and in No. 19.

[5] P. Manson: Notes on 2 Cases of Febrile Tropical Splenomegaly and a Suggestion: British Med. Journal, Vol. II., p. 1261.

[6] L. Rogers: On Kala Azar: Milroy Lectures, 1907; British Medical Journal, February and March 1907.

[6a] L. Rogers: British Medical Journal, 1904, Vol. I, p. 1249.

[7] Leishman: Journal of Royal Army Medical Corps, 1905, Vol. IV, p. 321.

[8] Donovan: British Medical Journal, 1903, Vol. II, p. 79.
Ibidem 1905, Vol. II, p. 1401.
Lancet, 1904, Vol. II, p. 744.

[9] L. Rogers: Development of flagellated organisms from the spleen protozoic parasites of Kala Azar: Quarterly Journal of Microscopic Science, Vol. 48, Part III.

— Further work on the development of the Herpatomonas of Kala Azar and Cachexiel Fever from Leishman-Donovan bodies. Proceedings of the Royal Society (Lond.) B. Vol. 77, 1906.

[10] Chatterjee: Lancet, 1905, Vol. I, p. 16.

[11] Christophers: Scientific Memoirs, Govt. of India New Series No. 8, 1904.

[13] Ronald Ross: British Med. Journal, 1903, Vol. II, p. 1261. Ibidem Vol. 1903, Vol. II, 1401: Ibidem, 1904, Vol. I, p. 160.

been provisionally styled by Minchin,[12] Leishmania tropica to distinguish it from Leishmania Donovani, the parasite of Kala Azar.

The object of the present research is an attempt to see if developmental and flagellate forms of the parasite of the oriental sore could be demonstrated in culture, and, if so, what similarity or difference could be established between the developmental stages of the two so similar parasites producing such dissimilar diseases.

The sero-sanguineous discharge squeezed out of a skin lesion (looking like a syphilide), when smeared on a slide and stained, presents the usual characters found in the oriental sore as will be seen in plates (I, I*a* and I*b*). They call for no special notice beyond the one or two following points. The parasites are seen in a variety of forms, from spherical to oval, ovoid and even elongated into cigar or torpedo shapes. The last however is different from the first three forms in its generally showing one central well defined and condensed nucleus and having the hyaloplasm staining bluish; in the first three forms the nuclei are two in number, the usually seen large wooly macro-nucleus and the small well defined dot like micro-nucleus and the protoplasm of the body of the parasite stains light pink. It appears thus that in the long forms, which are generally found outside the cells, the macro-nucleus has fused with the micro-nucleus, and as they bear a strong resemblance to the early alteration forms of the parasite in culture (as will be seen presently), it may be assumed that they represent a higher developmental condition than that of the other three forms, which are seen mostly packed within the body of the macrophage where they increase in numbers apparently by a process of multiplication by fission until they are ultimately liberated in the serum to undergo the changes into long forms as indicated above (some of these are figured in plates I, I*a*, I*b* and II).

Methods Adopted.

The material used for the above smears was collected aseptically and planted (A) in 2 per cent. Sodium Citrate in Sodium Chloride 0·8 per cent. solution, and (B) in blood serum (human); some were left at the laboratory temperature (25-28°C) while others were incubated at 35°C. And day after day subcultures were made, and smears from these cultures and subcultures were fixed, stained in Geimsa's stain, and examined in the usual way. The following is a summary of the preliminary results.

Preliminary Observation leading to the choice of the Culture Medium.

A. Citrate cultures at laboratory temp. 25-28°C—after 24 hours. No clearly defined parasites seen—some appeared swollen and macerated and could be distinguished only as altered parasites.

Citrate cultures at 35°C—after 24 hours no parasites visible—only granular debris and dots looking like altered nuclei noticed: evidently the parasites had disintegrated.

B. Serum cultures at laboratory temperature 25-28°C. The parasites had increased both in size and numbers. They were oval or ovoid and pear-shaped taking on a deeper blue stain, the nuclei being deep purple. The size was double or triple that of the parasites found in smears.

Serum cultures at 35°C—after 24 hours: the parasites had greatly diminished in numbers; some were swollen and indefinite in outline—apparently altered, but the majority showed appearances of granular degeneration.

After this preliminary observation no further examination of the incubated cultures was made, all attention being directed to the serum cultures grown at the laboratory temperature except on one occasion when a smear from the citrate culture (grown at the laboratory temperature for forty-eight hours) showed a few developmental forms; but as these were few and far between no further examination of them was made.

The developmental stages of the parasite can be divided according to its three or four distinct changes in size and shape, and, for descriptive purposes, the following nomenclature has been adopted in this paper.

(I) Precultural stage.

(II) Early preflagellate stage where increase in size, division and multiplication are in progress.

(III) Mature preflagellate stage where the relative position of micro-nucleus and macro-nucleus is determined and the trace of the future flagellum is obvious—after this no division of the individuals takes place.

(IV) The flagellate stage where the individuals, after reaching their full development as regards their body as well as the flagellum, swim about freely in the serum. After this no further development can be seen.

I. Precultural Stage.

When the juice from the sore is left to itself, in all probability the multiplication of the parasite, as it occurs in the lesion, continues and the parasites increase in numbers. Smears from such preparations show no changes in the shape of the parasite. They are perhaps a little larger than those taken from the sores direct. A little inequality in size and a paler pink tint of the hyaloplasm is all that can be noticed. Plate IV & Plate IV (1).

II. Early Preflagellate Stage.

Plate IV, 2-3 & Plate IV*a*, 3′-3″.

It is only when the parasites (above noted) are planted in a favourable culture medium at the proper temperature (25-28°C) that the first indication of early development comes into view, and this consists in the fusion of the well defined and sharply staining dot-shaped micro-nucleus with the less defined large woolly macro-nucleus: the whole resulting nuclear mass being a condensed single nucleus placed on one of the sides of the ovoid, looking very much like the single nucleus of the elongated forms of the original smears.

Simultaneously with this fusion, or soon after it, the body protoplasm both increases in size and alters in its staining properties, the pink tint of the hyaloplasm is

[12] Minchin in Clifford Allbutt's System of Medicine, Vol. II, Part II, page 55.

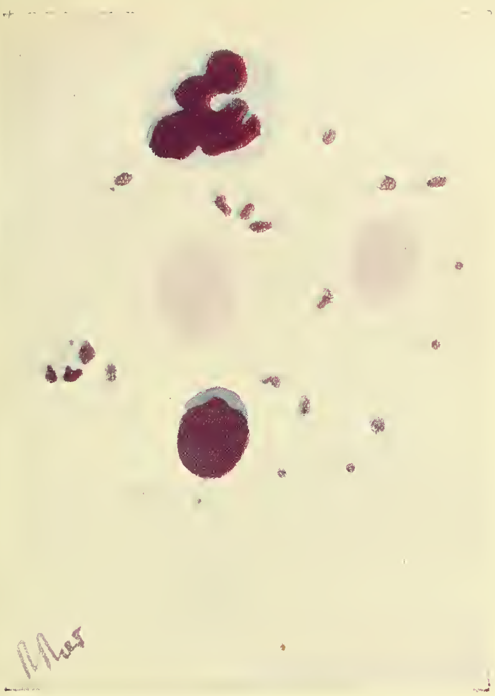

Plate I.

This illustrates what is seen in smears made direct from the discharge of the "Oriental Sore."

N B.—The large number of spherical and elongated torpedo shaped parasites. The former taking up a light pink stain and having the more or less centr l macronucleus and the small dot shaped eccentric micronucleus, and the latter taking up a light blue stain and having generally only one condensed nucleus.

Plate III.

This shows the form of the parasite in precultural condition when it was allowed to live and multiply in the discharge from the "Sore" for 3 days in vitro at room temperature 25—28° C (before manipulation for culturing).

N.B.—The slight increase in size and a little inequality in the size of the parasites and the extremely faint pink stain of the hyaloplasm. Some parasites are seen to be about to divide by fission.

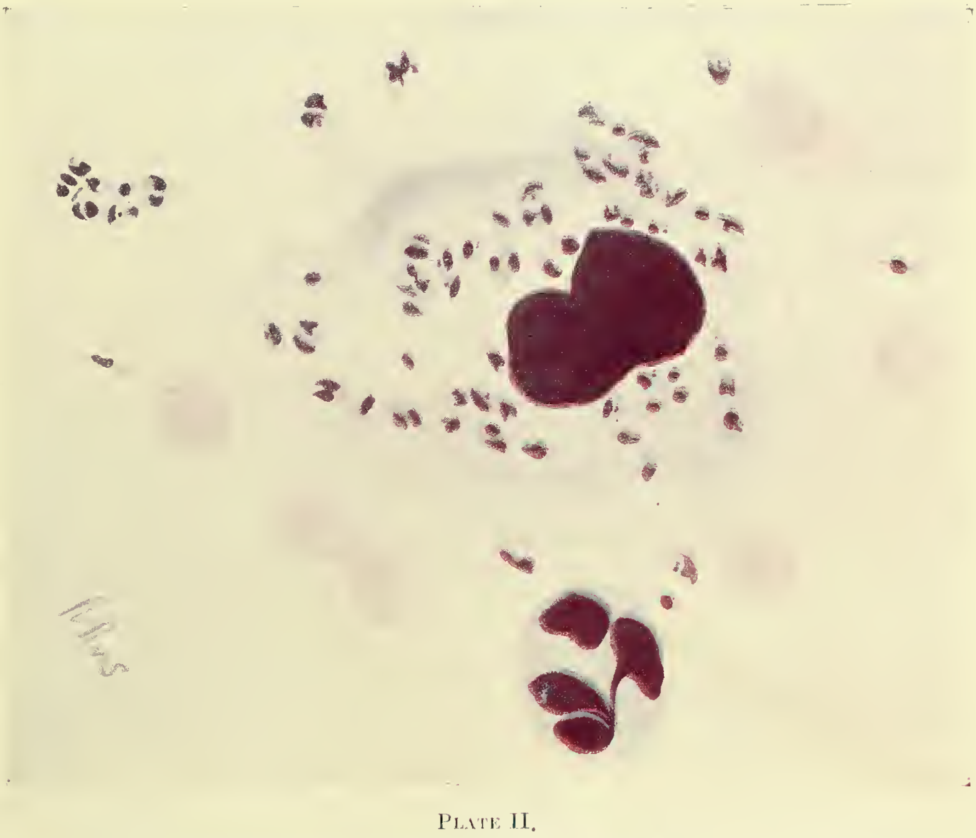

Plate II.

This illustrates also smear preparation from the discharge of the "Sore" direct.

N B.—The large polymorphonucleur macrophage containing the spherical parasites. Some of these and others of the elongated kind are seen outside the macrophages

Plate IV.

Illustrates the changes the parasite undergoes in 24 hours culture in blood serum at room temperature (25—28
"early proflagellate" stage during which multiplication is just started.

N.B.—Increase in size and alteration in shape of the parasites: Some are oval and ovoid while others are like pears pointed at one extremity. The nucleus is one condensed mass by fusion of the micro and macro-nucleus in some bean-shaped or kidney-shaped and sometimes elongated and tailed at one end.

1, 2, 3, 3′, 3″ = indicate the progressive stages of development from the precultural condition 1 up to all shapes observed in 24 hours.

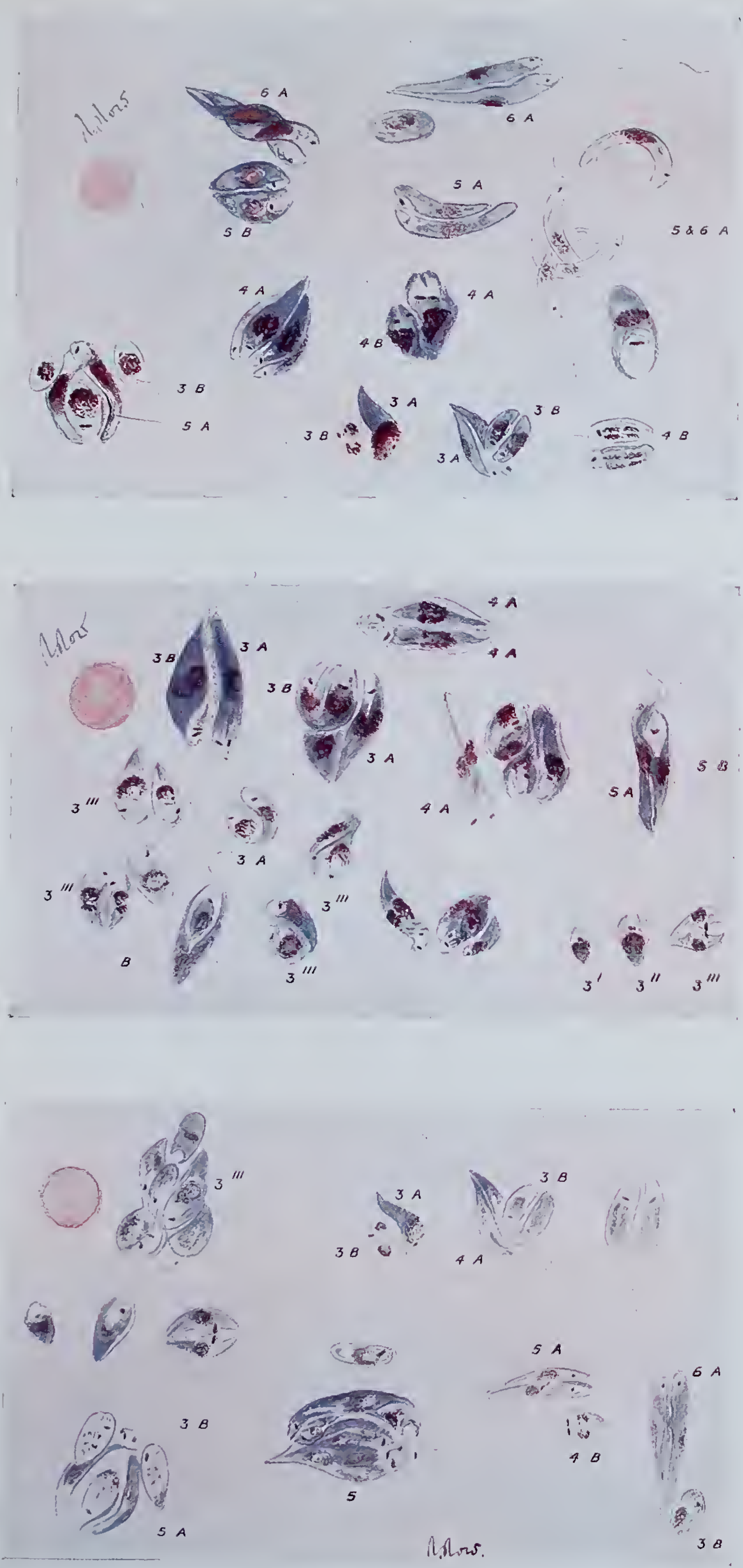

Plate IV (a).

A composite plate to illustrate the various stages of development from the early preflagellate stage into the mature preflagellate stage—in conditions of slow development. 48 hours culture in blood serum at 25—28° C.

N.B.—The different sizes and shapes of the parasite from oval, ovoid and pointed pear into long-tailed and curved banana-like bodies of the mature preflagellates. Mark also the relative position of the macro and micronuclei which is now definitely settled.

This plate illustrates also the formation of long forms and short forms from one individual under irregular conditions of growth a a_1 a_2 a_3 representing the evolution of short forms and b b_1 b_2 b_3 the development of long forms. Mark also the possibility of 8 individuals resulting from one single parasite of the precultural stage c c_2.

3′. 3″. 3‴. 3A 3B 4A 4B 5A 5B 6A = progressive stages of development from young preflagellate 3′ up to fully formed mature flagellates 6A in 48 hours culture. 3A. 4A. 5A. 6A indicate development of long forms and 3B. 4B. 5B indicate development of short forms as primary, secondary and tertiary derivatives from the original single parasite.

PLATE V.

Illustrates mature preflagellate stage in 48 hours culture in blood serum at 25—28° C.

N.B.—Culture masses of curved·banana like·bodies—with a central wooly macro-nucleus and small well defined dot or short rod like micro-nucleus situated a. the broader or anterior extremity. Mark also the vacuole-like appearance in the neighbourhood of this and also the trace of the future flagellum.

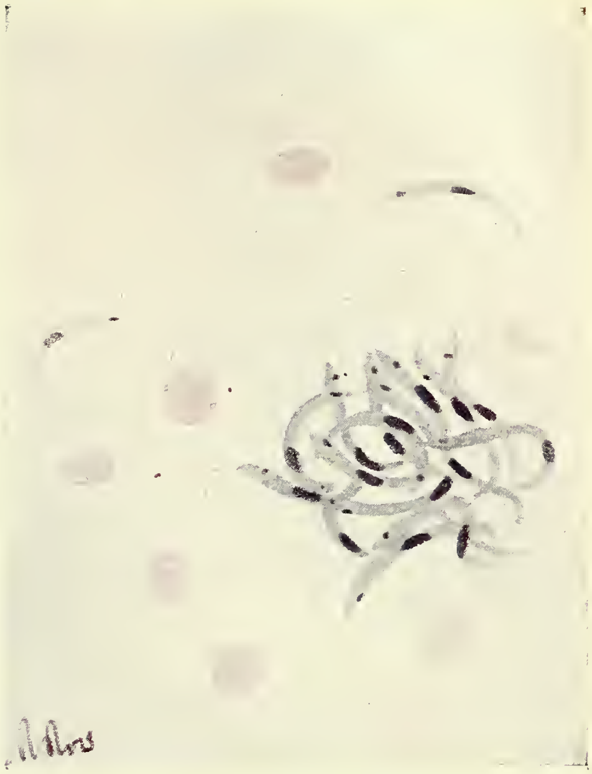

PLATE VI.

Illustrates the appearances of young flagellate stage of the parasite in 72 hours' cultures in blood serum at 25—28° C.

N.B.—The groups appear like those seen in Plate V but with the addition of a flagellum—which is 1½ the length of the body and shows 6 to 8 broad uniform undulations.

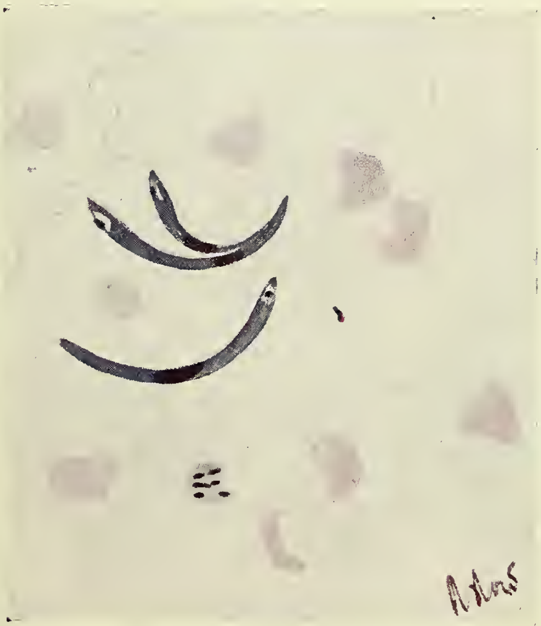

PLATE VII.

Fully formed young flagellates which have set themselves free from the masses and are found swimming freely in the culture of 72 hours in blood serum at 5—28° C.

PLATE VIII.

Mature flagellates 96 hours' culture in blood serum.

replaced by a pale bluish stain. The nucleus now elongates into a bean or kidney shape, or even becomes tailed at one of the extremities, and then begins to show a tendency to divide by giving off a bud from its free side. This increases and carries with it its own share of hyaloplasm ; thus we get a fission-form of an early preflagellate consisting of two individuals, and these by further division and sub-division by Karyokinesis split up again and again until a group of 8 preflagellates is derived from a single cell of the precultural stage. Plate IV*a*, 3‴.

III. Mature Preflagellate Stage.

Plate IV*a* : 4A, 5A, 4B, 5B & Plate V.

The development of these in favourable conditions is so rapid and uniform that by the end of 36 hours we get large masses of hundreds of these preflagellates which, in their full development, appear as bunches of curved banana-like structures (Plate V). As the preflagellates are about to assume some sort of individuality during their development, the differentiation of the nuclei and their relative position is determined. The micro-nucleus is budded off from the portion of the nuclear mass proximal to the broader pole or anterior extremity of the parasite ; it is placed nearer the macro-nucleus, and transversely to the long axis of the parasite, and looks rod-shaped and constricted, almost bisected in the middle, giving a suggestion of the possibility of a further subdivision—or sometimes it travels towards the anterior extremity and is then placed either obliquely or without any definite relation to the long axis of the body of the parasite (which then appears as a mature preflagellate), and here it develops round itself a faint vacuole in which, or out of which, the trace of the future flagellum becomes faintly visible as a fine bristle. Plate IVA, 4-A & 4-B.

IV. The Flagellate Body.

Plates VI, VII & VIII.

The development from the preflagellate into the flagellate condition seems to be rather rapid, so that one can see some of these even in a 48 hours' culture, and in a 72 hours' culture no preflagellates are ever found. The flagellate body is a preflagellate which has slightly grown in all dimensions and has a freely motile wavy flagellum at its anterior broader extremity where it is seen attached to or arising from the micro-nucleus. It is set free either from the complete absorption of the original faint capsule-like membrane, the remnants of the capsule of the original cell in which all its primary, secondary and tertiary derivatives are packed, or by their (flagellates) liberating themselves with the help of the now freely moving flagellum which is thrust out of the micro-nucleus situated at the broader anterior extremity of the parasite. The flagellate body is nearly 4 times the length of the diameter of the red corpuscle and about 2/3 this in its broadest part. The flagellum itself is $1\frac{1}{2}$ times the length of the body and it shows 6 to 8 regular wavy undulations (like those seen in spirochetes but wider) and it can be traced, as stated above, to the micro-nucleus. The living flagellate is an actively motile organism ; it swims in fresh preparations by pushing itself with a remarkable rapidity by virtue of the wavy and undulating movement of the flagellum (placed anteriorly). No other contractions of the body of the parasite can be noticed in the living specimen : the nucleus can be made out as the condensed part of the body of the parasite. No contractile vacuole or granules are visible. The vacuole observed round the micro-nucleus is also made out in fresh specimen by its appearing as the faint portion of the parasite. The author has been able to observe the motility in a single flagellate for over 24 hours when the parasite becomes stationary, the movement of the flagellum being the only index that life exists. After this the flagellum also loses its motility and the parasite dies and undergoes disintegration rather rapidly, so that in a 120 hours culture smear no more than granular patches indicative of the remnants of the macro-nucleus and a few detached flagella is all that can be seen.

SUMMARY AND CONCLUSIONS.

From the above I conclude that the parasites of the Oriental sore (L. tropica) and those of Kala Azar (Leishmania Donovani), although apparently identical when examined in smears direct from the lesion, are distinct when examined in cultures, and I summarise these conclusions for the following reasons :—

(1) The parasite of the Oriental sore when fully developed into the flagellate form, under ordinary conditions of culture, is much longer and bigger than that of Kala Azar in which one meets with short and fat forms as a rule.

(2) The parasite of the Oriental sore is more resistent to external conditions than that of Kala Azar—in other words it is much less delicate as it is found possible to obtain developmental forms up to the flagellates from this parasite (of the Oriental sore) three days after the parasites are removed from the lesion—while the parasite of Kala Azar according to Rogers dies within 24 hours after it leaves the spleen, if it is not cultured within that period.

(3) The flagellum of the parasite of the Oriental sore is much longer and presents more regular wavy undulations than that of Kala Azar where it is shorter and where the undulations if any are not regular nor uniform.

(4) Although contamination of the material with extraneous germs is inhibitory to the early developmental progress of the parasite of the Oriental sore, it is not so destructive to its further development into flagellates as in the case of the parasite of Kala Azar where, according to Rogers, even the slightest contamination with Staphylococci is sufficient to destroy the culture.

(5) The parasite of the Oriental sore develops into fully mature flagellate forms between 48 and

72 hours, while that of Kala Azar takes twice as long if not longer.

(6) The best culture medium (according to my results) for the parasite of the Oriental sore is human blood serum, by preference that from tuberculous patients, while that for the parasite of Kala Azar is, according to Rogers, sodium citrate 2 to 8 in sodium chloride 0-8 solution mixed up with splenic puncture blood.

(7) The optimum temperature for the growth of the parasite of Oriental sore is between 25 & 28°C, or even up to 30°C, while for that of Kala Azar it is 22°C, or even less (according to Rogers).

DISCUSSION.

Major Rogers said :—I should like to congratulate Dr. Row in the brilliant piece of work he has done in the successful cultivation of the parasites of Delhi boil. Further studies of the cultural forms should furnish data for deciding whether the parasites of this disease are identical with those of Kala Azar or if they are different, but closely related parasites. It is clear from Dr. Row's results that the general course of the development is on precisely similar lines to those of the Leishmania Donovani of Kala-Azar, but, although it is too early to allow of a positive opinion being formed, it appears to me that there are points of difference, such as the much more elongated and sausage shaped preflagellate stage, with its more oval and larger nucleus, in the Delhi boil parasite, which point to its being a different species from that of Kala Azar. Again, Dr. Row obtained good development up to a temperature of 28 C or 82 F, while one of over 25 C is fatal to the fever producing organism, which also requires sterile conditions at all stages, while Dr. Row informs me that in the flagellate stage of his cultures the presence of staphylococci does not injure their growth. The absolutely different distribution of the two diseases in India has always made me regard them as likely to prove quite distinct. Dr. Row's further work will be awaited with great interest.

Surgeon-General Hamilton in closing the section referred to the excellent and useful work done, and said that he hoped the outcome of the interesting papers and discussions would be fruitful.

Dr. Temulji B. Nariman proposed a cordial vote of thanks to Surgeon-General Hamilton for the ability, courtesy, and success with which he had discharged the onerous duties of the president of the section, which was unanimously carried.

Surgeon-General Hamilton in replying thanked all the members of the section for their co-operation, and said that whatever success was achieved was due to the Secretary of the section, Khan Bahadur Dr. N. H. Choksey, whose excellent management had contributed to the smooth and efficient working of the section. The credit of the success of the section was therefore due to Dr. Choksey.

Sir Gerald Bomford's Remarks.

Sir Gerald Bomford, Director-General of the Indian Medical Service, in addressing the section before it dispersed, said that although he had not taken any active part in the deliberations of the Congress, he had been an observer and listener, and had greatly appreciated the papers and discussions. He had many functions and duties to perform and had therefore to watch all that was going on in India in matters medical and scientific. Being the responsible adviser of the Government of India, he had to guide and advise it in all such matters to select proper men for work and research, to allocate money for the same, and to see that it was properly and rightly applied. He had therefore to be in close touch with the profession. What a vast contrast there was between the Congress at Calcutta of 14 years ago and the present. Then section after section made pungent strictures and passed resolutions complaining of the apathy of Government in relation to scientific research. This was being not only hampered but actually frowned down, and any attempt at original research met with scant encouragement, much less approbation at the hands of the higher officials. Now all was changed. Plague had given great impetus to scientific research and the present Congress testified to the outcome of the stimulus afforded by the visitation. Men were now enthusiatic about the help they received from Government. He was sometimes inclined to doubt whether all the money was rightly spent, but from what he had seen and heard at the Congress he no longer entertained any such doubts. Enthusiasm in matters scientific had reached now to such a pass that difficulty often arose when men asked to be taken at their own valuation and became dissatisfied if that was not done. Scientific ardour should however be moderate and not fervent or frantic as characterised by one of the speakers to day. In concluding he said that he had intended to be a silent listener, but had been compelled to break his silence in view of the excellence of the work he had seen, and expressed his best thanks to the readers of the papers, and those who had taken part in the discussions.

SECTION III.

(ANIMAL PARASITES AND DISEASE CARRIERS, SNAKE VENOMS, BERI-BERI, MYCETOMA, LEPROSY AND ELEPHANTIASIS.)

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DR. A. POWELL, B.A., M.B., M.Ch.

Assistant Secretary.

CAPTAIN L. P. STEPHEN, M.B., I.M.S.

Presidential Address by Surgeon-General P. H. BENSON, M.B., I.M.S., President of the Section.

The section I have the honour to preside over covers an enormous field, and I take it that any effort should be directed to limiting the subjects we are met to discuss, whilst bringing out the points which promise to be most fruitful in discussion. Of parasitic insects, *i.e.*, insects proper, exclusive of ticks, I have but a limited choice, fleas and mosquitoes being outside the province of my subject. The chief members of this group occur in the order diptera, the only representative of any other order being the bed bug (Cimex Lectularius). As far as India is concerned we have no diseases transmitted by the diptera to man, although the blood-sucking flies, for instance, Tabanus and Hæmatopota belonging to the Tabanidæ, one of the largest of all the families of diptera, harbour flagellates akin to the so-called "natural trypanosomes" of the tsetse fly of Africa. The only disease we have in India due to a flagellate is kala-azar, a disease which has existed in Assam since 1869, but attained to epidemic proportion in the early seventies. This complaint is limited, as far as the Madras Presidency is concerned, strictly to the municipal limits of Madras city. Patton states that he has discovered in the bed bug the real transmitter of this disease. The feeding experiments are by no means easy, and confirmation of Patton's find is still wanting as Donovan, Christophers and Rogers have all failed. The bug is cosmopolitan, and it is difficult to believe that a local disease like kala-azar, as it undoubtedly is in Madras, can be transmitted by the ubiquitous bug. Facts would point to a transmitter much more local in its distribution, for instance, a kind of tick. In the kala-azar occurring in Tunis the tick, louse or flea parasitic on the dog is suspected to be the transmitter. It is true that out of 158 dogs examined in Algiers Nicolle found Leishmania present in the viscera of three. So there is no doubt the dog harbours the same parasite as man, and a transmitter common to both is therefore to be sought. No attempts have been made as yet in Madras with a view to detecting the presence of the parasites in the pariah dogs of George Town—the most infected area in the city—but Donovan hopes to commence a search next April when the dog killing operations begin. Recently it has been stated that body lice act as transmitters of relapsing fever, but as this fever is absent in my presidency I am unable to offer any remarks anent the subject.

The common house fly is incriminated in the spread of enteric fever and when one is cognisant of the complex pad of the feet of the fly no doubt can be held of its acting as a direct transmitter.

I have very little to say, to you, gentlemen, regarding snake venoms. The varieties of poisonous snakes found in the Madras Presidency are very similar to those in other Presidencies and the remedies employed are much the same. Great expectations were at one time hoped for from the employment of Calmette's anti-venene which he claimed to possess anti-toxic properties against all kinds of venoms, but as Major Lamb, whose work in this direction is so well known will tell you, observers are agreed that anti-venomous sera are highly but not strictly specific, and the latest serum prepared at Kasauli, which is made of a mixture of Cobra and Daboia venoms, is only useful against bites from one or other of these species, so that a great deal remains yet to be done before any single serum can be prepared which will prove beneficial against all and every venom. As regards the treatment suggested by Sir Lauder Brunton, *viz.*, the introduction of permanganate of potash, though cases of cure have been reported from its use, I fear that little reliance can be placed on it.

Beri-beri has a very limited distribution in the Madras Presidency, being present only in the low lying portions of the eastern districts of Nellore, Guntur, Kistna, Godaveri, and Vizagapatam. Why it should be confined

to these districts and not be present in as suitable spots lower south is hard to explain. Paddy cultivation in low lying situations is as common south as well as north of Madras, where apparently the same variety of rice is grown. Nothing very new has been discovered as to the cause of this disease, but that the consumption of rice is in some way connected with the causation of the ailment cannot, I think, be disputed. Especially rice prepared in certain ways may develop a poison which is not destroyed by boiling, and this poison taken continuously may bring about the disease. The forms of rice suspected by the advocates of the rice-poison hypothesis are those in which the rice is prepared from the paddy by husking without previous boiling or steaming. It is believed that the husk contains a fungus which is able, after the grain is husked, to penetrate into the bruised and decorticated grains. It is further supposed that only certain crops, or the rice from certain places, contain the fungus, and therefore it is only a small proportion of the eaters of this class of rice who will be attacked. But though we have no conclusive evidence as yet to show that rice is a factor, and the relationship with the disease is still "sub-judice" I consider that the experiments carried out by Dr. William Fletcher, at the Lunatic Asylum at Kuala Dampor Selangor in 1905, and those of Dr. Leonard Braddon in 1907-08 so ably described in his paper shortly to be read, go a long way to prove that the specific poison is contained, so far as is at present known, only in rice or the products of its digestion when consumed in a certain state. Beri-beri is considered by some to be identical with epidemic dropsy, epidemics of which disease have been reported recently from Calcutta and its neighbourhood. But there are marked differences between these two affections.

Myeetoma or Madura Foot is, as you all know, a disease of warm climates and principally endemic in India usually affecting the foot. It is caused by the presence in the skin and under-lying tissues of a streptothrix closely allied to but differing from the ray fungus of actinomycosis. The name "Madura foot" is said to be derived from the district of Madura as it is rife there but this is not the case as the disease is local here. Cases do occur towards the south and east of this district but in small numbers, with nothing like the same frequency as in the northern districts of the Presidency. Its distribution is limited to what is called the black cotton soil areas, though the streptothrix has never been discovered in this soil, and the districts in the Madras Presidency where it exists commonly, are Guntur, Nellore, Anantapur, Bellary, Cuddapah and Kurnool, also the isolated patch further south in the S. E. of Madura and north of Tinnevelly district. There are several varieties, originally called streptothrix Madura, and the fungi giving rise to the disease are numerous; at least six have been formulated by Manson in his recent Huxley Lecture. The popular view is that the entrance of the Babul thorn into the foot is the most frequent mode of the entrance of the fungi into the human body.

In the case of such a loathsome disease as leprosy, numbering, as it does, so many victims throughout the length and breadth of the country, it appeares to me that our efforts should mainly be turned to the finding of a remedy for the relief of those affected. Up to date no reliable remedy has been discovered, and, whilst some advocate the hypodermic injection of mercury and idoform, others pin their faith in the application of X rays. It is fervently to be hoped that the latest remedy, Nastin, recently discovered by Dr. Deycke which possesses the property of dissolving the fat which the Lepra-bacillus is said to be encapsulated in, will prove efficient, and the papers on this subject will, I am sure, be listened to by all with great interest. Major Rost, who has devoted much time and attention to this subject, and who some years back thought that in 'Leprolin' he had discovered a cure, informs me that he has isolated an acid-fast bacillus from a leprous nodule very like the bacillus of leprosy which grows luxuriantly on milk, whilst retaining its acid-fastness, and that this organism grown in a particular medium and sterilised produces even better results when injected into leprosy patients than that originally used.

It may be taken for granted that elephantiasis is caused by Filaria, although attempts have been made recently by a certain Surgeon Sir Havelock Charles to deny the relationship of the worm with the disease. Manson's views, I think, clearly point to the filaria being incriminated. (In confirmation of his opinion Surgeon-General Benson quoted a portion of Daniel's address at the last British Medical Association's meeting at Sheffield, apropos of the subject.)

Elephantiasis is common in Madras, all along the coast where the water is salt or brackish. The distribution of the disease so closely connected with salt water gives me reason to think that there must be a causal relationship between it and filariasis. The disease is transmitted by the mosquito, but no particular species of the genera Culex or Anopheles is especially implicated. May not a kind of mosquito freqenting brackish water only be the special transmitter and not several genera of Culicidæ indiscriminately, as is at present taken for granted? Then, again, it has not been very satisfactorily proved that filariæ are transferred to human blood solely by the bite of a mosquito, although this theory has been very readily, and I consider without sufficient positive evidence, adopted by nearly all writers on filarial disease in man. A stumbling block in the mosquito bite transmitting theory is the case of Cochin, where elephantiasis and filariasis are very common. Here it is the poor native population, who drink the water from shallow pits dug in the sand of the island of Cochin, that suffer, the water in these pits being full of mosquitoes in all stages of development, while the well-to-do natives and Europeans, who procure their drinking water from a river several miles inland are free from this disease. The rich and poor live close together, and if the mosquito transmitted the disease by its bite, why should the rich and non-local water drinkers be free from elephantiasis and the poor neighbours who drink water locally be the sufferers? This is a good case in point and requires careful consideration before Manson's old view of filaria transmission is discarded.

ON TSETSE FLIES AND TRYPANOSOMIASIS.

By E. D. W. GREIG, M.D., F.R.S.E.,

Captain, Indian Medical Service.

INTRODUCTION.

The study of tsetse flies and the diseases disseminated by them is not only of scientific interest but of great practical importance. This becomes apparent when it is remembered that several hundred thousand inhabitants of Uganda alone have lost their lives from Sleeping Sickness, which is a tsetse fly disease. In Africa Sleeping Sickness has become one of the greatest scourges of recent times. As there is constant communication between India and Africa, it seems desirable for us to carefully consider the facts already discovered by the scientific investigation of this disease and the agent which spreads it; it is especially appropriate to deal with this subject in this Congress at Bombay, which is the great portal of India.

In April, 1903, I was deputed by the Government of India to proceed to Uganda to join the Sleeping Sickness Commission of the Royal Society. This Commission was very fortunate in having at its head so distinguished an investigator as Colonel (now Sir David) Bruce, F.R.S., to solve the very difficult problems which presented themselves, namely, the causation of this mysterious disease and how it was spread from the sick to the healthy. These questions, as this paper will show, were conclusively answered by the work of the Commission. After Colonel Bruce left for England, I carried on the work of the Commission with Lieut. A. C. H. Grey, R.A.M.C., until the end of 1904, and then proceeded from Uganda along the course of the Nile to Egypt, investigating the distribution of the tsetse fly and Sleeping Sickness.

In this paper it is proposed to deal with the investigations of the Commission in Uganda and the work done by others on this subject since that of the Sleeping Sickness Commission, whose researches formed the starting point for a large number of important enquiries.

The results of the Commission were summed up as follows:—

1. That Sleeping Sickness is caused by the entrance into the blood and cerebro-spinal fluid of a species of Trypanosome.
2. That this species is probably that discovered by Forde and described by Dutton from the west coast of Africa, and called by him Trypanosoma gambiense.
3. That the so-called cases of trypanosome fever, described from the west coast, may be, and probably are, cases of Sleeping Sickness in the earliest stages.
4. That monkeys are susceptible to Sleeping Sickness and show the same symptoms, and run the same course, whether the trypanosomes injected are derived from cases of so-called Trypanosome fever or from the cerebro-spinal fluid of cases of Sleeping Sickness.
5. That dogs and rats are susceptible, but that guinea-pigs, donkeys, oxen, goats and sheep, up to the present, have shown themselves refractory.
6. That the Trypanosomes are transmitted from the sick to the healthy by a species of Tsetse fly—*Glossina palpalis* and by it alone.
7. That the distribution of Sleeping Sickness and *Glossina palpalis* correspond.
8. That Sleeping Sickness is, in short, a human tsetse fly disease.

Before proceeding to discuss in detail the subject of this communication it may be well to state in broad outline the main points connected with the problem before us. For this purpose I cannot do better than reproduce a few paragraphs from an essay by Sir Ray Lankester,[1] who marshals the facts in admirably lucid language. He writes that "The Sleeping Sickness of tropical Africa furnishes an example of one of the innumerable directions in which man brings down disaster on his head by resisting the old rule of selection of the fit and destruction of the unfit, and is painfully forced to the conclusion that knowledge of Nature must be sought, and control of her processes eventually obtained."

[2] "Before the arrival of man—the would-be controller, the disturber of Nature—the adjustment of living things to these surrounding conditions and to one another has a certain appearance of perfection. Natural selection and the survival of the fittest in the struggle for existence lead to the production of a degree of efficiency and harmonious interaction of the units of the living world, which, being based on the inexorable destruction of what is inadequate and inharmonious as soon as it appears, result in a smooth and orderly working of the great machine, and the continuance by heredity of efficiency and a high degree of individual perfection."

"Parasites, whether microscopic or of larger size, are not, in such circumstances, the cause of widespread disease or suffering. The weakly members of a species may be destroyed by parasites, as others are destroyed by beasts of prey; but the general community of the species, thus weeded, is benefited by the operation. In the natural world the inhabitants of areas bounded by sea, mountain, and river become adjusted to one another."

"Anything like the epidemic diseases of parasitic origin with which civilised man is unhappily familiar seems to be due either to his own restless and ignorant activity or, in his absence, to great and probably somewhat sudden geological changes—changes of the connections and therefore communications of great land areas."

[3] "Human epidemic diseases, as well as those of

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1 "The Kingdom of Man." Constable, London, 1907. Preface.
2 Do. do. do. do. P. 184.
3 Do. do. do do. P. 187.

cattle and crops, are largely due to this unguarded action of the unscientific man."

[4] "We are justified in believing that until man introduced his artificially selected and transported breeds of cattle and horses into Africa there was no Nagana disease. The Trypanosoma Brucei lived in the blood of the big game in perfect harmony with its host. It was not until the Arab slave raiders, European explorers, and India-rubber thieves stirred up the quiet populations of Central Africa and mixed by their violence the susceptible with the tolerant races."

"Infectious disease, it was long ago pointed out, must be studied from three main points of view :—(i) The life history and nature of the disease germ or infective matter; (ii) the infected subject, his repellant or tolerant possibilities, and his predisposition or receptivity ; (iii) the intermediary or carrying agents."

We now pass to consider the subject in detail and will commence with the study of

I.—THE TSETSE FLY. *

(1) *General Characters.*—Among the members of the order Diptera or two-winged flies there are many which play an important part in the causation of disease in man and animals. Diptera may be characterised shortly as insects with one pair of wings, a thorax fused into a single mass, and mouth-parts adapted for piercing and sucking or for suction alone. (Austen). The Tsetse fly (*Glossina*) belongs to the family Muscidæ which contains the House fly (*Musca*) Blue and Green bottle flies (*Lucilia* and *Calliphora*), Stinging or stable flies (*Stomoxys*) and Horse flies (*Hæmatobia*).

It will be desirable to allude briefly to the chief characters of the genus *Glossina* before considering its role in the propagation of disease. To those desirous of exhaustively studying the characters of the *Glossina*, a most complete account of them will be found in the excellent Monograph of Austen.[5]

Austen characterises the Tsetse fly as follows :—

"Tsetse then may be described as an ordinary looking sombre brownish or greyish brown flies varying in length from $3\frac{1}{2}$ to 4 lines ($7\frac{1}{2}$ to 10 millimetres) in the case Glossina morsitans to about $5\frac{1}{2}$ lines ($11\frac{1}{2}$ millimetres) in that of Glossina fusca or longipennis with a prominent proboscis in all species. The hinder half of the body or abdomen in the best known species, though not in all, is of a paler colour and marked with sharply defined dark brown bands which are interrupted on the middle line ; the abdomen, however, is invisible when the insect is at rest, as it is then concealed by the wings. The sexes of Tsetse flies can readily be distinguished when specimens can be examined, since in the male the external genitalia form a conspicuous knob-like protuberance (hypopygium) beneath the end of the abdomen which is absent in the females."

(2) *Species of genus Glossina.*—The genus Glossina includes the following species :—

1. Glossina palpalis—
   (The transmitter of T. gambiense, the causal agent of Sleeping Sickness).
2. Glossina morsitans—
   (The transmitter of T. Brucei, the causal agent of Nagana,)
3. Glossina pallidipes.
4. Glossina longipennis.
5. Glossina longipalpis.
6. Glossina fusca.
7. Glossina tachinoides.
8. Glossina maculata.
9. Glossina pallicera.

The fly with which we are more particularly concerned, in connection with disease in man, is the Glossina palpalis as it is this fly which has been demonstrated to be the carrier of Tryp. gambiense, the causal agent of human trypanosomiasis (Sleeping Sickness), as well as three varieties of animal trypanosomiasis—"Jinga cattle disease," "Mule disease of Uganda" and the "Abyssinian fly disease."[7] The Glossina morsitans has been proved to be the carrier of the Tryp. Brucei, the causal agent of Nagana, a disease which in certain parts of Africa has killed off all domestic animals. There is some evidence to show that other varieties of tsetse fly, *e.g.*, Glossina fusca,[8] may convey the parasite of Sleeping Sickness as well as Glossina palpalis. This important problem will no doubt be studied by the New Sleeping Sickness Commission in Uganda.

(3) *External Features of Tsetse Fly.*—The external characters of Glossina are shown in the drawing (after Austen) :—Fig. 1.

At first sight the Tsetse fly is not unlike an ordinary house fly. On closer observation, however, it will be seen that it differs markedly from it. It has in front a long and straight proboscis with which it sucks blood. When at rest the fly assumes a very characteristic attitude, the wings are crossed over one another like a pair of scissors and they project well beyond the abdomen, and the proboscis stands out horizontally in front of the head. This attitude is an important sign by which the tsetse fly can be distinguished from all other blood-sucking Diptera, especially from those belonging to the genera Stomoxys and Hæmatopota.

[4] "The Kingdom of Man." Constable, London, 190 . Pp.189-190.

[5] "Monograph on Tsetse Flies" by E. E. Austen, British Museum.

* The attention of Members of the Congress is directed to an exhibit by Mr. F. M. Howlett, Imperial Entomologist, showing a series of specimens illustrating the characters of Glossina palpalis and other biting flies. He will also give a lantern demonstration on this subject.

Specimens of Glossina palpalis, male and female, as well as the pupæ are being exhibited by the present Sleeping Sickness Commission, Uganda.

[6] Sleeping Sickness Report of Royal Society, No IV. Bruce Nabarro, Greig.

[7] Do. do. do. do. No. VI. Greig and Gray.

[8] Do. do. do. do. No. V.

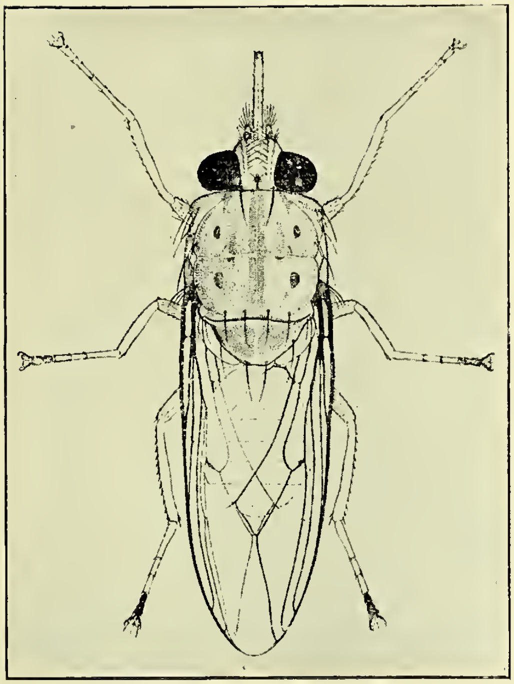


Fig. 1.

A Tsetse Fly (Glossina Longipennis, Corti, from Somaliland) in resting attitude, showing the position of the wings. (× 4). (After Austen.)

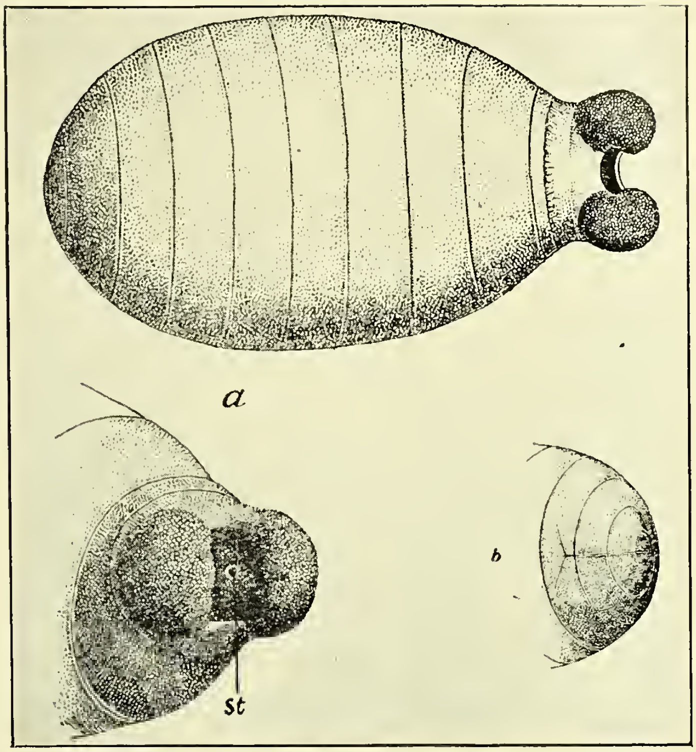


Fig. 2.

Pupa of Zululand Tsetse Fly, dorsal aspect (× 12); *a* posterior extremity, showing pit and right larvel stigma, *St* (× 24), *b* anterior extremity, showing bifurcated longitudinal seam, which opens to permit the escape of the imago (× 8). (After Austen.)

Fig. 3.

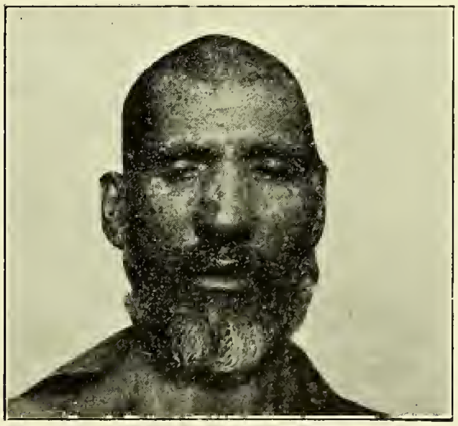
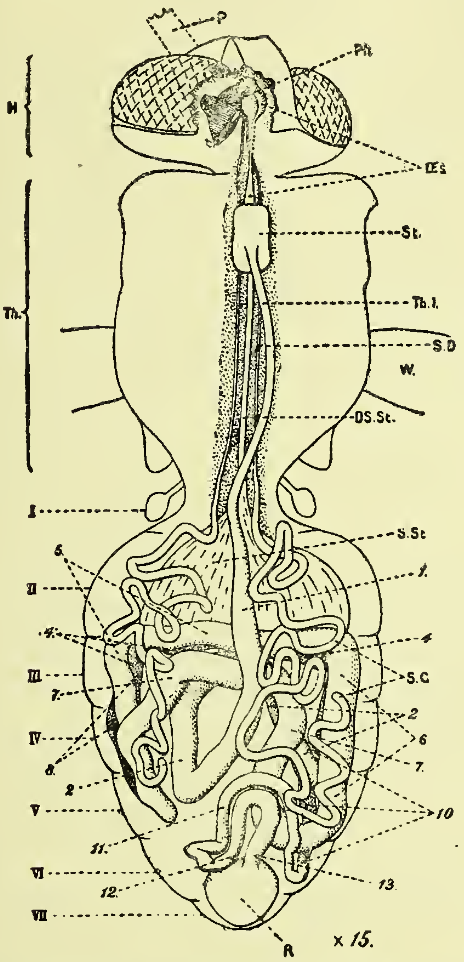


Fig. 4.

(4) *Internal Anatomy of Tsetse fly.*—The following photograph shows the internal anatomy of the fly (from Sleeping Sickness Report, No. VIII, Royal Society).



Ph., pharynx ; Œs., œsophagus (the portion which passes through the brain being represented with a dotted outline); St., proventriculus ; Th. l., thoracic intestine pulled over to the right, in order to show the duct of the sucking stomach lying beneath it ; S. D., salivary duct; D.S. St., duct of; S. St., sucking stomach ; S. G., salivary gland (that on right is drawn from a specimen in which the gland was more developed than in the case of that drawn on the left); 1-13, limbs of the abdominal intestine; I-VII, the segments of the abdomen. H. head ; Th., thorax ; W, origin of wings ; P., proboscis.

(5) *Habits.*—By means of mouth parts the fly is enabled to draw up blood rapidly and after feeding the abdomen appears enormously distended like a small cherry. Both male and female suck blood. Bagshawe[1] thinks that where human blood is obtainablo the female fly predominates, and that females wander further in search of food than do the males. He has shown that Glossina palpalis would travel along the course of a river or shore bank more than a mile to return to its former haunts. When the Glossina attacks man or animals its flight is direct and makes a slight buzzing sound. It frequently strikes men on the back of the neck which is generally naked. It gives a sharp prick with its proboscis ; this is frequently the first indication of the presence of the fly as it alights very gently. The bite does not leave much irritation, not so much as a mosquito sting. They are generally most active during the hot part of the day, becoming drowsy towards evening when they may be caught on the leaves of trees. Ensor,[2] however, states "that in the Bahr-el ghazal province of the Soudan the tsetse fly, Glossina palpalis, is most active from about sunrise to 10 a.m. and from 4 p.m. to sunset." They are said, however, to be active on moonlight nights—an important fact, as it is customary to take animals through "fly areas" at night to avoid the bites of the fly.

The tsetse fly, unlike other Diptera, has a remarkable distaste for ordure. For this reason it is rarely found in the neighbourhood of towns or habitations.

(6) *Fly Belts.*—The flies occur in well marked tracts, the so-called "Fly belts" of Africa. Austen states : "We are still somewhat in the dark as to the factors that determine the limits of theso 'belts,' but, although the tsetse fly is undoubtedly dependent upon the blood of wild animals for its continued existence, all recent evidence goes to show that the most important element is the physical character of the locality ;" also as an explanation of the "Fly belts" he says "although not 'social' insects in the ordinary sense of the term as applied to animal communities, Diptera, as a whole, show a marked social tendency on the part of individuals of the same species although without exhibiting anything in the shape of mutual aids."

The Glossina palpalis is generally found near water and requires a cool shady not too dense undergrowth to thrive in, and, if in addition to this, the water is covered by a growth of ambatsch vegetation (Aeschynomene elaphroxylin) the Glossina are generally particularly numerous. Hodges[3] considers that the range of the flight of the tsetse fly from water is as follows :—"Natural range," *e.g.*, ordinary flight from water 10 to 30 yards, rarely 50 yards ; "following rango," *e.g.*, the distance from waterside the fly will follow a man or animal passing through a "fly area," 300 yards. When the dry sand gives place to shady undergrowth and when there is no shade from the sun and no moisture we cease to find the tsetse fly. This is well seon in passing from the country round the great lakes of Central Asia (Lake Albert and Victoria) through the Soudan towards Egypt.[4] In Egypt the tsetse fly has not been found so far although it exists in a small portion of the Soudan, the physical conditions of which are suitable for the existence of the fly. Glossina palpalis is not found in Uganda in open grassy spaces.

(7) *Food Supply.*—Glossina lives exclusively on blood. It is a most greedy and rapacious bloodsucker. It will feed on frogs, snakes, crocodiles and birds as well as mammals ; the association of the fly and big

[1] Reference R. A. M. C. Journal, Vol. XI, July 1908.

[2] Reference R. A. M. C. Journal, Vol. XI, July 1908.
[3] Do. do. do. do. do.
[4] Sleeping Sickness Report of Royal Society, Vol. VI., Greig.

game, especially buffaloes, has been long recognised; if they do not have blood they very soon die.

Koch[5] considers that tsetse flies are particularly partial to the blood of crocodiles. He states that the skin between the scales of the crocodile is quite thin and soft and easily penetrated by the proboscis of a tsetse fly. He states, also, that he has found in the stomach of the fly quite fresh crocodile blood. As we have seen, however, the fly by no means exclusively sucks the blood of crocodiles, but is prepared to feed on the blood of animals without much discrimination. Koch has recommended the extermination of crocodiles in Africa by destruction of their eggs, in order to destroy the tsetse flies, and so prevent the spread of Sleeping Sickness by cutting off the food supply of the transmitting agent. Without discussing the effects of such a procedure on the prevention of Sleeping Sickness, the task of eradicating all crocodiles from the shores of the great lakes of Central Africa would be so gigantic, as to be outside the scope of practical preventive measures. The part played by the crocodile as a food supply for tsetse flies is being investigated by a Commission in Uganda under Sir David Bruce.[6]

The tsetse flies frequently enter the native canoes and alight on the backs of the rowers, and I have observed them carried in this way for many miles from the islands on Victoria-Nyanza to the mainland of Uganda.

(8) *Seasonal Prevalence.*—Trustworthy information as to the seasonal prevalence of the tsetse fly is still wanting.

(9) *Mode of Reproduction of Tsetse Flies.*—From the scientific as well as the practical point of view, a knowledge of the mode of reproduction and the conditions in nature favourable to this function is a matter of great importance, as it may be possible to apply this knowledge to the problem of destruction of the fly and by this means to prevent the spread of disease. The tsetse fly is peculiar in that it does not lay a number of eggs, but only a single larva, and this rapidly becomes transformed into a pupa.

The larva when first extruded is yellow in colour and immediately after birth creeps about with a good deal of activity. It was formerly surmised that the tsetse fly was bred in buffalo dung, and hence the close association between the fly and the buffalo. This view has been proved to be incorrect. As Austen[7] points out, in their mode of reproduction, the tsetse flies "exhibit a remarkable similarity to what takes place in the group of parasitic flies which, on account of their peculiar mode of reproduction, have been termed Puppipara" example being Hippobosca equina, Linn, a well-known plague of horses and cattle in the New Forest; other species occur in Africa and India and are found on horse, cattle and dogs.

The drawing (after Austen) Fig. 2., shows the pupa of the tsetse fly.

[5] Deutsche Med. Woch. No 51, December 20th, 1906.
[6] British Medical Journal, June 1908.
[7] Monograph on tsetse flies. Austen.

Austen[8] gives the following measurements of the Pupa of Glossina morsitans :—

Extreme length $6\frac{1}{3}$ to 7 m.m.
Greatest breadth $3\frac{1}{3}$ to $3\frac{2}{3}$ m.m.

The colour is dark-brown, except in the case of the last segment which is deep black. It has been a matter of considerable difficulty to detect the larvæ in nature, but recently in Uganda Bagshawe[9] has demonstrated for the first time that the pupæ occur frequently about the roots of banana trees. Zuspitza[10] has also found pupæ of palpalis on trees of every kind from a height of a few c.m. to $3\frac{1}{2}$ metre, also in humus and in thick layers of moss. It is found very frequently in palms. Some recent work by the French Sleeping Sickness Commission is of interest in this connection. Roubaud[11] has studied the reproduction of Glossina palpalis and, as a result of his observations, arrives at the following conclusions :—

(1) That the mean life of the female Glossina is about three months and a series of 8 to 10 pregnancies represent the fecundity of the insect; as a single larva only is laid each time it will be seen that the tsetse fly is not very prolific. (2) The dimensions of the larva are 6 m.m. $\times$ 3 m.m. (3) The larva distorts its shape and inflates its cephalic end with blood which it uses as a rammer. (4) The larva seeks a dry place; it does not move more than 5 c.ms. (5) Having found a suitable place they immobilise and condense and in less than 45 minutes they are transformed into a mould or pupa. Length of pupa 6 m.m. Breadth $3\frac{1}{7}$ m.m. Weight 0·025 to 0·028 grams. (7) In captivity abortion is not uncommon. This was previously pointed out by the Sleeping Sickness Commission in Uganda in Report No. VI, p. 209.[12] We state "a point of considerable interest in connection with the flies is the tendency which they have to abort in captivity." (8) The mean duration of the nymphal life is 33 days. (9) A temperature about 25° C is the most favourable. Roubaud is of opinion that this explains the peculiar distribution of the fly in thick shady vegetation near water.

Roubaud[13] brings forward the following additional facts as a result of his researches :—

1. As in the nymphs, the habitat of the adult fly is determined by the physical conditions of temperature and moisture of the place.

The most suitable conditions are a night temperature of 25°C, a day temperature of 30°C and a constantly high degree of humidity.

Flies after feeding on blood were placed in tubes and the temperature raised to 25°C and no further nourishment given:—

Result. 1. In dry air (dried with potash). It survived one day.

[8] Monograph on tsetse flies. Austen.
[9] Nature, P. 630, Oct. 1906.
[10] Archiv für Schiffs und Tropen Hygiene. Bd. XII Heft 6. 1908.
[11] Comptes Rendus Hebdomadaire de l'Academie des Sciences. Tome CXLVI No. 7, 17th February 1908.
[12] Greig and Gray.
[13] Comptes Rendus Hebdomadaire de l'Academie des Sciences. Tome CXLVI No. 7, 17th February 1908.

2. In normal air of Laboratory. (about 70% moisture). It survived 6 days.
3. In moist chamber (air saturated). It survived 13 days.

The temperature was raised to 33°C (same experiments).

1.	Air dry	18 hours.
2.	Air normal	1 day.
3.	Air saturated	6 days.

Hence we see a dry hot climate is inimicable to the reproduction of the tsetse fly.

So far the genus Glossina has not been discovered in India: an explanation of this may be possibly an absence of the necessary physical conditions, namely, a moderate temperature and a very high degree of moisture.

2. In the fly belt the Glossina localises by choice in certain localities, either associated with the presence of man or large game.

These points of election, where the Glossina, abundantly nourished, remains stationary and multiplies, may be called "Fly Centres".

The "Centres" will be defined by the physical conditions and nutrition. In places where game abound the fly may extend all along the river owing to food being assured; where game is rare then the "Centres" (Gites) are limited to the points where animals ford the river. In regions entirely deprived of big game the fly is found exclusively in the neighbourhood of men, *e. g.*, points of river near villages, encampments, caravan routes, etc. Certain "Fly Centres" persist throughout the year with a slight diminution in the dry season, these are the "Permanent Centres" developed close to permanent water where conditions of humidity and of temperature do not change. The "Fly Centres" near small courses of water, which dry more or less completely in dry season, are "Temporary Fly Centres."

3. The Glossina travels along the bank of the river and the "Permanent Fly Centres" constitute the reservoirs of flies and feed the "Temporary Centres."

The above facts regarding the life history of the Fly are not only of considerable scientific interest, but are of great practical importance in connection with the problem of the prevention of sleeping sickness.

The measure which suggests itself as most practical is the clearing of a zone at the point of the "Fly Centre." By this means one acts at once on the adult flies by modifying the physical conditions which permit them to live in the "Centre" and on the nymphs, because by slight elevation of temperature the conditions become unfavourable to their development.

It is particularly necessary to concentrate attention on the "Centres" where many infected human beings or animals are congregated together.

(10) *Geographical Distribution of Tsetse-flies in Africa.*—Austen, of the British Museum, has prepared a map showing the general distribution of tsetse flies (Genus Glossina, Wiedemann) *vide* Fig. 1. From a study of this map it will be seen that the fly is very widely distributed. The importance of such a map is obvious, because, with an exact knowledge of the "Fly belts," rules can be laid down to prevent infected persons from entering country where the fly is known to exist and thus it may be possible to keep "Clean Fly Belts" free from the disease. Thus a barrier is opposed to the forward march of the disease. One of the chief problems of the recently established Bureau for Sleeping Sickness in London is to collect data in order to map out precisely the distribution of the Glossina palpalis and Sleeping Sickness over the whole of Africa.[1]

III.—DISEASES DISSEMINATED BY THE TSETSE FLY.

(1) *Tsetse Fly Disease of Animals.*—Nagana or the classical tsetse fly disease of animals renders thousands of square miles of Africa uninhabitable. No horses, cattle or dogs can venture, even for a day, into the so-called "fly country." At one time it was thought that the tsetse fly killed the animals by injecting a poison into them in the same way as a snake kills its prey, until the investigations of Bruce in 1895 showed for the first time that the disease is caused by a minute blood parasite (Trypanosoma), and that this parasite was conveyed from the sick to healthy animals by the bite of a variety of tsetse fly (Glossina morsitans). He further showed that the wild game harboured the parasite without showing any signs of disease. They were immune or "salted" to this disease, and acted as "reservoirs" of the parasite; as soon as they were killed off or driven away, the tsetse fly disease disappeared, as occurred in the great Rinderpest epidemic amongst the buffaloes in 1906. Further the disappearance of the big game deprived the tsetse fly of a source of food and so the numbers of tsetse flies became reduced.

Since 1895, in addition to Nagana, a number of other trypanosome diseases of animals transmitted by tsetse flies have been worked out.

It was demonstrated[2] that the following diseases in animals were caused by trypanosomes, and further it was proved by the Sleeping Sickness Commission that the Glossina palpalis can convey the trypanosomes, found in animals in Uganda affected by these diseases, from the sick to the healthy animals and so propagate these diseases:—

The "Jinga Cattle Disease" of Uganda.
The "Abyssinian Fly Disease."
The "Mule Disease" of Uganda.

Roubaud[3] has shown that the Glossina palpalis can transmit T. dimorphon, the cause of Gambia horse disease, from the sick to the healthy animal.

A few facts about these trypanosome diseases of animals which we investigated in Uganda may be of interest.

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[1] British Medical Journal, June 1908.

[2] Greig and Gray. Report No. VI, Sleeping Sickness Commission of Royal Society.

[3] Annales de L'Institute Pasteur, XXI, 1907, pp. 466-467.

The "Jinga Cattle Disease"[4] affected a fine herd of cattle which had been brought into Usoga from the Bukedi country, near Mount Elgon. These animals were apparently quite healthy before leaving Bukedi. They were marched through the "Fly country" and on their arrival at their destination, Jinga, Usoga, numbers of them became sick and died. We investigated this outbreak and found, as stated, that the disease was caused by a trypanosome and transmitted by the tsetse fly. We were able to show, that in Uganda the tsetse fly was responsible not only for appalling loss of human life, but serious stock diseases as well.

As further illustrating the danger of taking "unsalted" animals into fly belts, the facts connected with the disease, which occurred amongst the animals of the Abyssinian Boundary Commission, are of interest.[5] The animals of the Commission affected were eleven Boran and Abyssinian ponies, as well as several camels and five English dogs. These all died. None of the Abyssinian donkeys or mules were affected. Austen in his monograph p. 326 records, that a variety of tsetse fly (Glossina fusca) has been found on the north-east shores of Lake Rudolph, which is in the country where these animals contracted the disease. One of the infected animals, a dog, was examined by us and found to have a species of trypanosome in his blood and he died. We were able to demonstrate that this strain of trypanosome could be transmitted also by the tsetse fly (Glossina palpalis).

A sick mule in Uganda showed trypanosomes in its blood, this strain of trypanosome was transmitted from sick to healthy animals by the tsetse fly (Glossina palpalis).[6]

We see, therefore, that trypanosome disease was widely distributed amongst the animals in Uganda, as well as amongst men. The trypanosome, as we will learn later, which caused the human disease, T. gambiense, is quite distinct from that which causes the animal disease.

(2) *Tsetse Fly Disease of Man or Sleeping Sickness.*—In 1903[7] it was demonstrated for the first time, that, in addition to transmitting a fatal disease from animal to animal, the tsetse fly (Glossina palpalis) was responsible for the spread of Sleeping Sickness, a disease which has depopulated large tracts of country in the basin of the Congo and Central Africa. In Uganda alone it has swept off, in the course of a few years, several hundred thousand victims. This disease, like the disease in animals, is caused by a minute blood parasite—a trypanosome.

(*a*) *Geographical Distribution.*—The Sleeping Sickness has been known clinically on the West Coast of Africa for over a hundred years, but its cause and mode of spread remained a mystery until 1903.[8] It extends along the coast and up the river valleys from the 150 N to 150 S Latitude. With the opening up of Central Africa it has extended from the Congo eastward into Uganda to the north as far as Gondokoro on the Nile, and south to Lake Tanganika. It is now one of the most serious scourges of modern times. In Uganda the disease was first recognised in 1901 and appears to have originated in Busoga. The disease was probably introduced into this area from the Congo by the remains of Emin Pasha's Soudanese troops and followers, some 10,000 in number.

(*b*) *Clinical Features.*—It is not possible within the limits of this paper to enter into the clinical and pathological features of this disease. I would refer those interested in this question to the description given in the Reports of Sleeping Sickness Commission of the Royal Society. A few of the more important features of the disease may be mentioned in passing.

The incubation period of Sleeping Sickness, that is, the interval between the bite of the infected tsetse fly and the appearance of enlargement of the cervical glands in the neighbourhood, is according to Martin and Leboeuf, about 10 days.

The disease may be divided into two stages :—

(1) The stage of polyadenitis.

(2) The stage of polyadenitis with involvement of the cerebrospinal system.

In the early stage of the disease, the only definite clinical feature is a distinct enlargement of the lymphatic glands, particularly the cervical. This phase may be called the stage of Polyadenitis, and is accompanied by an increase of the lymphocytes in the blood. Enlargement of lymphatic glands has been recognised for a long period as a constant feature in the early stage of Sleeping Sickness and a connection with the disease surmised, but it was only recently scientifically shown what the relationship to the disease was.[9] On examination of the juice of these enlarged glands we were able to demonstrate the constant presence of trypanosomes in them ; thus the specific nature of the glandular enlargement was established, and, in addition, a ready method of detecting the parasite in the tissues of man was discovered. Gland puncture is now recognised as the simplest, quickest and most reliable method of diagnosing Sleeping Sickness in its earliest stages. The method has been practised in different parts of Africa, with success, by Dutton and Todd, Koch and others, and its efficacy fully confirmed by them.

The patient remains in the stage of Polyadenitis for a very varying period of time, sometimes for months, sometimes for years. The old slave dealers rejected negroes suffering from enlarged glands of the neck when offered for purchase, because they were of opinion that in the course of time they would die of Sleeping Sickness. The patient may have irregular attacks of fever, increased rate of pulse and headache ; but, apart from enlargement of glands, he, as a rule, shows no definite signs of disease, although he harbours the parasite. He is, in fact, a "carrier," a reservoir of the virus, and takes the place of the wild game in Nagana. As will be readily understood, such cases are a great

[4] Greig and Gray. Report No. VI, Sleeping Sickness Commission of Royal Society.

[5] Do. do. do. do.

[6] Do. do. do. do.

[7] Bruce, Nabarro and Greig. Report No. IV, Sleeping Sickness Commission of Royal Society.

[8] Bull. Soc. Path. Exot. t. L. F. 8th July 1908.

[9] Greig and Gray : Proceedings of Royal Society, May 1904.

source of danger, as they may easily escape detection, and by moving from one part of the country to another may infect "Fly Belts" that have been hitherto free from infection or "clean." The recognition of cases in this stage of the disease can be carried out by means of gland puncture, and we have, therefore, in this method an efficient and practical means for combating the spread of this disease throughout Africa, and also preventing the importation of cases of Sleeping Sickness into India and other countries. This question will be referred to more in detail when the methods for the prevention of the spread of the disease are discussed.

Sooner or later, the stage of Polyadenitis is complicated by signs and symptoms indicating involvement of the central nervous system. It was to this last stage of the disease that the name Sleeping Sickness was given. It is produced by the trypanosome gaining an entrance into the cerebro-spinal system, and producing there the characteristic pathological changes which were first described by Mott.[1] So far as present experience goes, when this stage is reached, the disease is invariably fatal. A number of cases die during the stage of enlargement of glands from intercurrent affections, *e.g.*, pneumonia, &c.

The disease attacks both black and white ; male and female ; young and old without discrimination.

As regards occupation, it will be readily understood what part this plays in the propagation of the disease, if we remember that the natives of Uganda carry on their trade on the shores of the lakes ; the goods (bananas, fish, etc.) being brought in canoes and sold there. This "market place" is in the "fly area," and many of the natives harbour the parasites of Sleeping Sickness ; hence all the factors necessary for the spread of the disease are present.

The photograph, Figs. 3 and 4, taken for the Commission by Mr. Stordy shows very well the faces of two cases of Sleeping Sickness.

The patient acquires a curious sleepy or drowsy expression, hence the name of the disease. If the patient be spoken to at this stage, he answers in a hesitating manner, and his lips and tongue show fine tremors. As a rule he is greatly wasted, his gait is uncertain, and, finally, he becomes completely bed-ridden. This last stage lasts about three to six months on an average. In some cases the patient develops symptoms of mental derangement, and may become maniacal. The temperature keeps above normal during this stage of the malady, but about a week or two before death it becomes subnormal and remains so.

IV.—SUMMARY OF OBSERVATIONS AND INVESTIGATIONS BY WHICH IT WAS ESTABLISHED THAT GLOSSINA PALPALIS CONVEYS THE TRYPANOSOMA GAMBIENSE, THE CAUSAL AGENT OF SLEEPING SICKNESS, FROM THE SICK TO THE HEALTHY.

1. *By Epidemiological Investigation.*—Before the arrival in 1903 of the Sleeping Sickness Commission, it was thought that the tsetse fly did not exist in Uganda at all ; but, when Sleeping Sickness was proved to be a trypanosome disease, the first endeavour was to ascertain whether or not tsetse flies did exist in Uganda. A short examination of the lake shore near Entebbe soon established the fact that a species of tsetse fly (Glossina palpalis) was present in large numbers at certain points. The next step was to determine the geographical distribution of this fly in Uganda. This was done through the agency of the Native Parliament, Government Officials and Missionaries. Instructions and apparatus for collecting biting flies were sent to all Native Chiefs, Officials, &c. It was requested that samples of all biting flies from their district should be sent to us at Entebbe, as well as the information whether or not Sleeping Sickness was present there. We examined each collection of flies for the presence of glossina. Several hundred batches of flies passed through our hands. We had two maps of Uganda, and if we found a tsetse fly in a collection from a district, a red dot was placed on the map at the point where the fly came from. If Sleeping Sickness was present, a red dot was placed on the same point on the other map. In this way we were able to map out the distribution of the Glossina palpalis and Sleeping Sickness in Uganda.

The accompanying maps show the distribution of Glossina palpalis in Uganda and the distribution of Sleeping Sickness in Uganda.

From a study of the above two maps it will be seen that the distribution of Sleeping Sickness is practically identical with that of Glossina palpalis. In districts where the fly is not found no cases of Sleeping Sickness occur. Cases of Sleeping Sickness are frequently imported into fly-free areas ; such cases die, but no spread of the disease takes place. The fact is all the more remarkable, because in these districts other biting flies exist in large numbers, *e.g.*, mosquitoes, horse flies, stomoxys, &c. The evidence from our epidemiological studies indicated very clearly that the Glossina palpalis was the chief, if not the only, agent in the propagation of Sleeping Sickness in Uganda. At the same time we were attacking the problems by—

(2) *Experimental Investigation*—The problems which we had to solve experimentally were : (i) To determine whether the fresh tsetse flies caught in the "Fly Belts," containing a population severely infected with the Trypanosoma gambiense, harboured the parasite ; (ii) To determine whether tsetse flies could convey the Trypanosoma gambiense from patients suffering from Sleeping Sickness to healthy monkeys.

As regards the first problem the method employed was to collect daily a large number of tsetse flies (Glossina palpalis) from the neighbourhood of Entebbe. These flies were brought into the laboratory and placed in cages. These cages were composed of a square wooden frame closed by mosquito netting to allow the flies to bite through. One side of these cages was placed on the abdomen of a monkey, the hair having been previously shaved off and the flies were allowed to

[1] British Medical Journal, Vol VI., p. 1666, 1899, and Report No. VII, Sleeping Sickness Commission of Royal Society.


MAP SHOWING THE
DISTRIBUTION OF
GLOSSINA PALPALIS.
The Black Dots show Localities
where Tsetse Fly was obtained.
Gondokoro
Lokoya
Bari
PROVINCE
Dufile
HIMULI
Fadibek
Shuli
Wadelai
RIVER NILE
Victoria Nile R.
Unyoro
ALBERT NYANZA
Unyoro
LAKE CHOGA
Mruli
(Buruli)
Elgon
Mt ELGON
Buyaga
Bugangezi
(Bugangadzi)
Singo
Bugerere
R. Nile
Usoga
Bulamwezi
(Bulemezi)
EAST AFRICA PROTECTORATE
Toro
Bwekula
Busiro
Kiadondo
Chagwe
Busuju
Gomba
(Butumzi)
Butambala
Mawokota
Entebbe
(Port Alice)
Mawogola
(Mahogoro)
Kabula
Buddu
LAKE ALBERT EDWARD
Sese Ids
Ankole
Koki
VICTORIA NYANZA
Anglo-German Boundary
Ft Shirati
Scale of Miles
0 10 20 30 40 50 60 70


MAP SHOWING THE DISTRIBUTION OF SLEEPING SICKNESS IN UGANDA.
The Black Dots show where Sleeping Sickness is prevalent.
The Crosses represent Cases imported from Sleeping Sickness area.
Gondokoro
Lokoya
Bari
PROVINCE
Dufile
NIMULI
Fadibek
Shuli
Wadelai
RIVER NILE
Victoria Nile R.
Unyoro
ALBERT NYANZA
Unyoro
LAKE CHOGA
Mruli
(Buruli)
Elgon
Mt ELGON
Buyaga
Bugangezi
(Bugangadzi)
Singo
Bulamwezi
(Bulemezi)
Usoga
Toro
Bwekula
Busiro
Chagwe
Busuju
Gomba
(Butunzi)
Butambala
Mawokota
Entebbe
Uvuma
EAST AFRICA PROTECTORATE
Mawogola
(Mahogoro)
Kabula
Buddu
LAKE ALBERT EDWARD
Sese Ids
Ankole
Koki
VICTORIA NYANZA
Anglo-German Boundary
Ft Shirati
Scale of Miles

bite. The number of flies which fed was noted. The blood of the monkey was examined for some time before the feeding operation was commenced and at regular intervals afterwards. In this way we infected healthy monkeys with Trypanosoma gambiense and were able to prove that the freshly caught fly (Glossina palpalis) harbours this parasite. As already mentioned the flies at this particular spot had ample opportunities of infecting themselves. The method adopted to determine whether the tsetse fly (Glossina palpalis) could convey the Trypanosoma gambiense from a patient suffering from Sleeping Sickness to a healthy monkey was as follows:—

Freshly caught flies were kept in the laboratory for 24 hours and then allowed to feed on a healthy animal, dog or monkey. The precaution was necessary to rid the flies of any trypanosomes they might have acquired naturally. After a time those flies were allowed to feed on a Sleeping Sickness patient and then at intervals of 8 hours, 12 hours, 24 hours and 48 hours, they were placed on healthy monkeys and allowed to bite them. The number of flies which had fed was carefully noted in each case. The blood of the monkeys was, of course, examined before commencing the experiment and proved to be free from trypanosomes. Trypanosoma gambiense appeared in the blood of monkeys on whom the flies had been fed at intervals of 8 hours, 12 hours, 24 hours and 48 hours, after feeding on a Sleeping Sickness case, but never at longer intervals than 48 hours.*

By these experiments we proved that up to 48 hours, but not longer, after feeding on a patient suffering from Sleeping Sickness the tsetse fly (Glossina palpalis) was capable of infecting a healthy monkey. The reason why the fly is not infective for longer than 48 hours, we shall see when discussing the fate of Trypanosoma gambiense in Glossina palpalis. If the view that Trypanosoma gambiense is spread by means of the tsetse fly is correct, then the population of a "fly area" should contain a higher percentage of infected persons than the population of a "fly-free area."

3. THE EXAMINATION OF THE POPULATION OF (1) AN "INFECTED TSETSE FLY AREA," (2) A "FLY-FREE AREA."

The methods adopted were, (*a*) the examination of 10 c. c. of blood which was kept from clotting by the addition of a small quantity of a solution of Citrate of Soda. The blood was centrifuged for 10 minutes. The clear plasma was decanted off and this again centrifuged for 10 minutes, and, if necessary, a third time. The principle of this method was to allow the heavier blood corpuscles to sink to the bottom, whilst the lighter motile trypanosomes remained suspended in the clear plasma. This clear fluid was centrifuged for a longer period to bring down the trypanosomes and a drop of the deposit was examined fresh under the microscope. (*b*) The examination of the enlarged cervical glands in the two areas was made by the method above detailed.

* Since writing the above an important observation of Kleine has just been confirmed by Bruce (April 3, 1909), which shows that glossina palpalis infected with T. Gambiense is still infective after 16, 19, and 22 days.

As a result of the above examinations, it became evident that 50 to 75 per cent. of the population of the "Infected Fly areas" in Uganda harboured the parasite of Sleeping Sickness and they were carrying on their ordinary work showing few or no signs of disease, glandular enlargement being the only constant feature; these persons take the place of the wild game in the case of nagana and act as "reservoirs" or "carriers" of the parasites. It is this class of case which is especially liable to infect "clean" fly belts.

The examination of the population in a "Non-infected or Fly-free area" showed that practically none of the inhabitants harboured the parasite and such as did had a history of exposure in an "Infected Fly area."

We see therefore that the evidence obtained from the various lines of research along which the problems were attacked conclusively established the fact that the parasite which caused Sleeping Sickness was conveyed from the sick to the healthy by means of the tsetse fly (Glossina palpalis).

We pass next to consider in detail the causal agent of Sleeping Sickness.

V.—THE TRYPANOSOME.

(1) *Historical.*—The first blood parasite ever made known to naturalists and medical men was that to which Gruby in 1843 gave the name Trypanosoma sanguinis. He found it in the blood of the common frog. No attention was directed to this parasite until it was rediscovered in 1871 by Ray Lancester. In 1878, Dr. Timothy Lewis found a parasite in the blood of rats in Calcutta and afterwards in the common sewer rat of London. It was named after its discoverer, Tr. Lewisi. Like the trypanosome of the frog, it seems to exist innocently in the rats' blood. In 1880, also in India, Evans made the epoch-making discovery that a Trypanosome was capable of causing a most deadly stock disease of India, "Surra." In honor of the discoverer it was called Tr. Evansi. From this date trypanosomes were recognised as parasites capable of producing fatal disease. The North African animal disease, "Dourine," was shown to be caused by a trypanosome, T. equiperdum. In 1895, the fatal disease of Africa, nagana, was clearly shown by the brilliant investigations of Bruce to be caused by a trypanosome, Tr. Brucei. Nextly, a disease of S. American horse ranges, Mal de caderas, was proved to be due to a trypanosome, Tr. equinum. So far it had not been suspected that trypanosomes were harboured by man, but in December, 1901, Forde and Dutton discovered in the blood of a West Africa patient, a trypanosome. This was called by Dutton, Tr. gambiense.[1] Previously in 1898, Nepven had described trypanosomes in the blood of man. This case of Forde and Dutton showed few signs of disease and the trypanosome was not in any way associated with Sleeping Sickness.

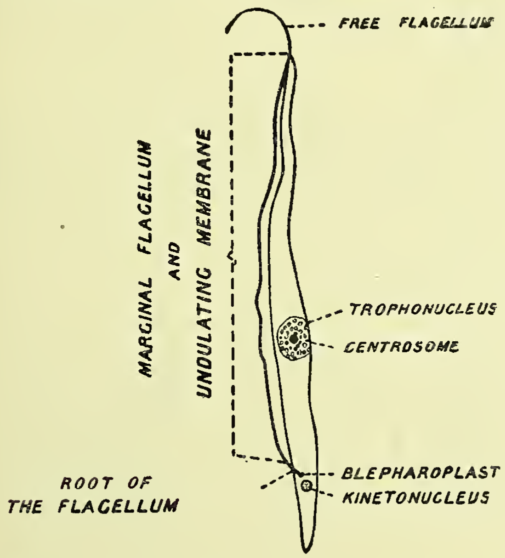
In 1903 the Sleeping Sickness Commission of the Royal Society in Uganda experimentally proved that the extremely fatal disease, Sleeping Sickness, was caused by a trypanosome, which was Tr. gambiense.

[1] Thomson Yates' Laboratory Reports, Vol. 4, Part 2, May 1902.

These trypanosomes are all very minute and have a somewhat elongated eel-like form, their average length is $\frac{1}{1000}$ of an inch. They are simple protoplasmic animals, consisting of one single nucleated corpuscle. They have no mouth; nutrition being effected by the imbibition of soluble nutrient material. When living they move rapidly about in the fluids of the body, being propelled by the contractions of a fin-like structure. They reproduce by a simple division; this is, so far as is known, the only method of reproduction of trypanosomes. Having sketched briefly the history of trypanosomes we pass next to consider:—

(2) *The trypanosome in the blood of the vertebrate host and in the Tsetse fly.*—A most careful study of trypanosomes in tsetse flies has been made by Professor E. A. Minchin,[1] who investigated the subject in Uganda as a Member of the Sleeping Sickness Commission from the beginning of April to the beginning of December 1905. I shall give a short account of his investigations.

(*a*) *Structure of trypanosome.*—The following diagram (after Minchin) shows the structure of the Trypanosome and the names applied to the various parts of it.



Trypanosomes as a rule travel with their flagellar end in front, but, if moving against a resistance, as in pushing their way amongst blood corpuscles, the flagellum of the undulating membrane is generally directed backwards.

As regards the nomenclature of the structural parts of trypanosomes, Minchin[2] states that "with regard to trypanosomes I may point out in the first place that the "micronucleus" is certainly a chromatic body and cannot be classed with achromatic structures. Apart from its staining reactions, which are more intense than those of the larger nucleus, I may cite the observations of Schaudinn, who describes it as arising in Trypanosoma noctuae by an unequal division of the zygote nucleus; and I may further draw attention to the condition in Trypanoplasma, where it is as large, or even larger than the other nucleus, so that the term micronucleus for it becomes rather a misnomer.

In the second place I may point out, as others have done also, that the flagellum does not arise from the smaller nucleus, but quite independently of it, from a minute basal granule. The behaviour of the flagellum and of the smaller nucleus in division also shows clearly their complete structural independence, as I have pointed out below.

I consider the basal granule of the flagellum as a true blepharoplast in the sense in which I have defined the term (Professor Minchin regards a centrosome as an achromatic body in connection with a nucleus; a blepharoplast as a body of the same nature as a centrosome, but in connection with a protoplasmic locomotor apparatus such as a flagellum or cilium); and I regard the nuclear apparatus of trypanosomes as specialised into two distinct portions, one regulating the function of locomotion, the other that of nutrition. Hence I consider that the terms kineto-nucleus and tropho-nucleus, suggested by Woodcock, express most correctly the true nature of these bodies.

From the true blepharoplast arises the flagellum, which passes to the surface of the body and runs along the edge of the undulating membrane as the marginal flagellum, until it reaches the end of the body, where it becomes a free flagellum of greater or shorter length."

A vacuole near the kineto-nucleus has been regarded almost as a normal feature of the species, but in Minchin's experience these vacuolated forms are very rare. He states "I have found them only in trypanosomes from the cerebro-spinal fluid, never from the blood, and in the former they are by no means universal."

(*b*) *Reproduction.*—This takes place by simple longitudinal fission, Minchin[1] has described the process of division in Trypanosoma Grayi. "The first event in the process of division is that the minute basal granule or blepharoplast of the flagellum divides into two. At the same time the kineto-nucleus becomes slightly enlarged and elongated." The flagellum then splits longitudinally. The next stage is the division of the kineto-nucleus. When the splitting of the flagellum is complete, the nucleus divides. When the division of the nucleus and flagellum is complete the body begins to split, starting from the anterior extremity between the two flagella. The two individuals are attached last in the neighbourhood of the kineto-nucleus, until finally they break loose.

Before leaving the consideration of the life of the trypanosome in the blood of the vertebrate host the investigations of Moore and Breinl may be referred to.[2] M. & B. have studied the development of T. gambiense in the blood of vertebrates.

[1] Quarterly Journal of Microscopical Sciences, Vol. 52, Part 2, March 1908.

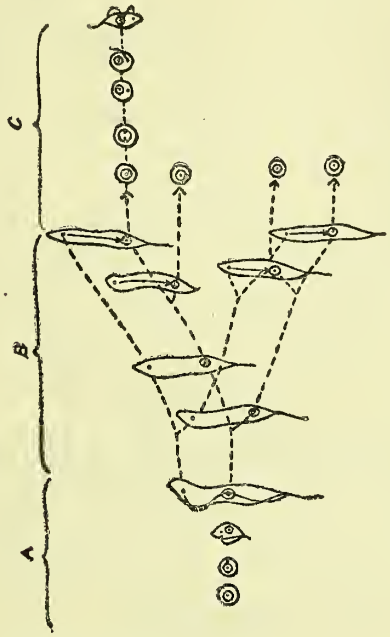
[2] Quarterly Journal of Microscopical Science, Vol. 52, Part 2, March 1908.

[1] Quarterly Journal of Microscopical Science, Vol. 52, Part 2, March 1908.

[2] Annals of Tropical Medicine and Parasitology, Vol. 1, No. 3.


AFRICA
SHOWING THE DISTRIBUTION OF THE
TSETSE-FLIES
AS AT PRESENT KNOWN.
Glossina tachinoides
Glossina palpalis
Glossina longipennis
Glossina morsitans.
Glossina fusca.
Glossina pallidipes.
Areas where two or more species have actually been found
Gl. palpalis . longipalpis . fusca . morsitans
Gl. palpalis . morsitans . longipalpis
Gl. fusca . palpalis
Gl. palpalis . fusca . morsitans . pallicera
Gl. fusca . morsitans . longipalpis . palpalis
Gl. palpalis . fusca
Gl. fusca . palpalis
Gl. morsitans . pallidipes
Gl. palpalis . morsitans . longipalpis
Gl. pallidipes . fusca
Gl. longipennis . fusca . pallidipes
Gl. morsitans . fusca . pallidipes
Gl. morsitans . fusca . pallidipes
Gl. pallidipes . fusca

The following diagram taken from their paper illustrates the cycle of development of T. gambiense in the rat:—



Diagram—Showing life cycle of Trypanosoma gambiense in a rat (after Salvin Moore and Breinl).

(a) Development of the trypanosome from the latent body.

(b) Fission of the Trypanosome and the formation of the black line.

(c) Reproduction of the latent bodies and the development of the Trypanosome therefrom.

Starting from the "Latent body" of the Authors the first process is the production of an extra-nuclear centrosome. A stage is reached at which what is called the "Black line" developes. "At this period the extra nuclear centrosome developes a bridge as it were, which connects itself for the time with the nucleus." "The remains of the extra-nuclear centrosome are very shortly cast away together with the greater part of the protoplasm forming the rest of the cell and the old flagellum." Briefly put "there arises from a nucleus A, two new structures B and C, both of which differ from A, B and C multiply independently as the animals (trypanosomes) divide, but at a subsequent stage a portion of each B unites again with the C in all the cells and the condition of the organism immediately reverts to A once more."

The Authors are of opinion that the T. gambiense can complete its life cycle in the rat, *i.e.*, vertebrate host. The Authors make the following important statement "that the blood although apparently containing no trypanosomes at all and even if it be properly filtered is still capable of infecting other animals into which it is introduced." In regard to this statement Minchin says[3] "I look forward with much interest to the publication by the Authors of the evidence on which it is based. At present they have given us none." Bruce and Bateman[4] conclude from a series of careful experiments that neither Tr. Brucei nor Evansi develop in the body of animals forms so small as to be capable of passing through the pores of a Berkefeld filter.

Moore and Breinl[5] have also studied the life-history of Trypanosoma equiperdum, the causal agent of Dourine of horses. This Trypanosome is not transmitted by a tsetse fly, but by sexual intercourse. The Authors say "that during the infection of rats with Dourine, that is to say with a form of trypanosome which under normal circumstances is not related to distinct hosts, there exists a life cycle among the parasites closely analogous to that occurring during the successive, positive and negative periods of infection of the same animals with T. gambiense." Recently Moore, Breinl and Hindle[6] have studied the life cycle of Tr. Lewisi. This Trypanosoma is found in a certain percentage of wild rats and appears to be non-pathogenic to them. They state "in briefly considering the foregoing observations upon the life history of T. Lewisi, the most striking biological feature which emerges is the obvious similarity that exists between the successive phases presented by T. Lewisi and the homologous phases occurring in the life cycle of T. gambiense."

In reference to the above mentioned researches it may be observed that Swellengrebel[7] has described a filament or band in Tr. Brucei, gambiense, and equinum (Mal de Caderas). He regards this, however, as a phase in the degeneration of the parasite. He says "on the intranuclear part of the axial filament (as he calls this band) granulations form which have a well marked red colour. These granulations do not remain in the nucleus, but leave it and proceed along the axial filament. Having arrived in the cytoplasm they disperse without delay by quitting the axial filament. In the cells undergoing degeneration, the nucleus becomes less and less stainable, whilst the granulations become more numerous and voluminous." Also "the forms with the axial filament (with or without granules deposited on it) seem to be the adult and vigorous forms. The appearance of the granules disseminated irregularly in the protoplasm seems to be the prodrome of degeneration."

3. *Trypanosomes in the Tsetse fly.*—In studying the trypanosomes in the tsetse fly, the first question to answer was whether the trypanosome underwent any developmental cycle in the tsetse fly similar to the life cycle of the malarial parasite in the mosquito. Minchin[8] went to Uganda to study the life cycle of Trypanosoma gambiense in the local tsetse fly, Glossina palpalis. His investigations on this point have yielded entirely negative conclusions. He never found any signs of T. gambiense later than the fourth day after infection.

[3] Quarterly Journal of Microscopical Science, Vol. 52, Part 2, March 1908.

[4] Proceedings Royal Society, B. Vol. 80, 1908.

[5] Do. do. do. do.

[6] Annals of Tropical Medicine and Parasitology, Vol. II, No. 3, 1908.

[7] C. R. Soc. Biolog. T. LXIV, No. 2, January 1908.

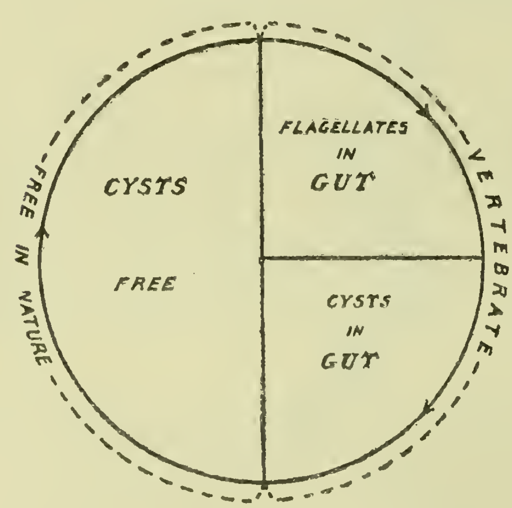
[8] Quarterly Journal of Medical Science, Vol. 52, Part 2 March '08.

He states[9] that "In spite of much searching T. gambiense was never found in any organs, except those in which digestion of blood was proceeding; that is to say, in the stomach and intestine." If the trypanosomes really die out on the fourth day Minchin is of opinion that Glossina palpalis is not the true host. If it is only apparent, the disappearance might be explained: (1) By supposing that they pass into other organs of the fly, but Minchin in his careful investigations never found a trypanosome or anything suggesting a trypanosome outside the digestive tract. (2) By supposing that they assume an ultra-microscopic form. (3) By supposing that they undergo encystation as Minchin[10] has shown takes place in T. Grayi. This later phase in the life-history of the trypanosome is a most interesting one and unfortunately Professor Minchin did not detect it until after he left Uganda and from want of further material was not able to elaborate this important discovery.

4. *Ancestral form of Trypanosomes.*—When discussing the subject of trypanosomes in tsetse flies, I have frequently had the question put to me, where did the trypanosomes originally come from? In answering this query I shall cite the views held by the chief authorities; and in the first place will quote the interesting hypothesis which Minchin[11] brings forward for the reconstruction of the successive stages in the evolution of the trypanosome life cycle. I have drawn the following diagrams to make clear the various stages.

Stage 1.

Ancestral Form.



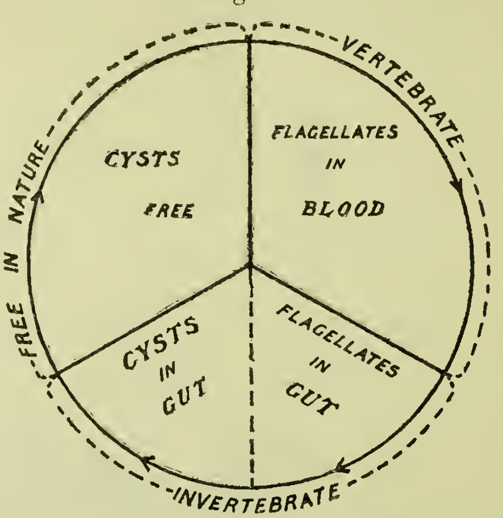
In this stage it was a flagellate, parasitic in the vertebral gut, disseminated by forming resistent cysts in the gut, which were scattered abroad and contaminated the food of fresh vertebrate hosts.

Therefore 2 phases only of this stage

1. In gut of vertebrate.
2. As cysts free in nature.

[9] Quarterly Journal of Medical Science, Vol. 52, Part 2, March '08.
[10] Do. do. do. do. do. do. do.
[11] Do. do. do. do. do. do. do.

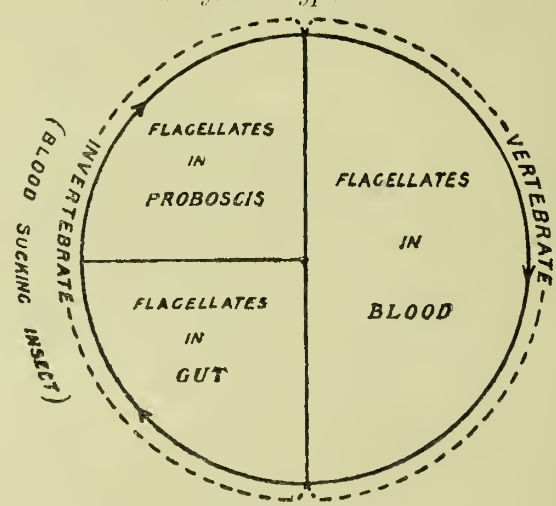
Stage 2.



In this stage the flagellate has succeeded in penetrating the intestinal wall of the vertebrate host and entered the blood stream. It can only escape by being taken up by a blood-sucking insect. It resists the digestive juices of the invertebrate host by forming cysts. The cysts pass out with the fæces and infect fresh vertebrate hosts by contamination.

Stage 3.

Pathogenic Trypanosomes.



The trypanosomes, having now become completely adapted to the invertebrate (tsetse fly) gut, acquires the power of passing forwards, till it reaches the proboscis of the fly and becomes inoculated into the vertebrate host; thus establishing the commonly occurring inoculative type.

It will be seen from the above that according to Minchin the ancestors of trypanosomes were primitively parasites of the gut of vertebrates, like so many flagellates known to exist at present, and that from the gut they passed into the blood of the vertebrate and finally into the gut of the blood-sucking invertebrate (*e. g.*, the tsetse fly).

The other school, which includes Leger, Brumpt and Novy, considers that the ancestor of the trypanosomes is primarily a parasite of the invertebrate host and only secondarily becomes a blood parasite of man. Leger[1] states "At first effecting their entire life cycle of evolution in the non-biting insects these herpetomonas become progressively modified in the case of those insects which become haematophages. Then the rich nutrient medium (the blood in the alimentary tract of the insect) causes an enormous multiplication of the parasites and they are prepared to live in the blood of the vertebrate host, where it finally reaches, on account of its small size and mode of feeding of its host. Then the trypanosome type is completed by the development of an undulating membrane, which I consider with Senn, Laveran and Mesnil, as a character of an adaptive nature in relation to the consistence of the medium (blood) in which the parasites live. The trypanosomes of the blood represent only an adaptation partial and secondary of a parasite, primarily intestinal and entero-coelomic of the invertebrate, and that explains why they should return to complete their sexual reproduction."

In conclusion the views of Minchin[2] are briefly summarised thus:—

(1) In Uganda Trypanosoma gambiense begins, but does not complete, a developmental cycle in Glossina palpalis, the method of transmission by this fly in this region being purely mechanical and direct.

(2) In other Diptera also, T. gambiense starts on a development in a precisely similar manner, but without getting so far, or persisting so long, as in Glossina palpalis.

(3) The observations and experiments of Koch, Stuhlman, and others show that T. Brucei goes through a developmental cycle in G. fusca.

(4) It is probable that T. gambiense has an invertebrate host in which it completes its life cycle in regions where it is indigenous, and it is possible that the true host may be Glossina fusca.

(5) Considerations of phylogeny indicate that the life cycle of different trypanosomes should not be expected to be in all cases of one invariable type.

(6) The encystation observed in T. Grayi indicates that contaminative infection may occur as well as the inculative.

5. *Explanation of Specificity of Tsetse Flies in the Transmission of Trypanosomes.*—As we have seen the observations indicate the part played by the Glossina, in the transmission of trypanosomes, is purely mechanical; hence the question arising, why do other biting flies not act in the same way? Considerable light has been thrown on this problem by the investigations of Roubaud,[3] member of the Mission Française d'Etudes de la Maladie du Sommeil. He studied four types of trypanosomes, Trypanosoma gambiense, T. dimorphon, T. Brucei and T. Cazalboui. In Glossina palpalis he found the 4 types of trypanosomes underwent essentially the same changes. At the end of 48 hours in the lumen of the proboscis an immense number of parasites was found and they were attached to the internal surface of the labrum by the extremity of the flagellum, especially in the bulbar region, and along the hypopharynx. When seen in the salivary juice without compression they are nearly immobile, but if a drop of salt solution or serum be added they vibrate rapidly in every direction, approaching the free extremity to the fixed as if to detach themselves. When free they swim with the flagellum in front and the posterior extremity rigid, thus differing from the original trypanosomes. The power of fixation is great and they will attach themselves to the slides whilst under observation. After staining it is seen that the free flagellum is remarkably thickened, like a small stem. The kineto-nucleus is in front of the tropho-nucleus and the undulating membrane has disappeared.

What are these singular parasites? Experiments show that they are a "temporary culture" of the trypanosomes ingested in the blood. Have they developed at the point of suction or have they ascended from the alimentary tube during the interval of feeding? In T. Brucei it was found that the trypanosomes died in the digestive tube of Glossina palpalis without multiplication a short time after ingestion. The culture in the proboscis was found on the contrary to persist for 5 to 6 days. The trypanosomes under the influence of the special properties of the saliva, move rapidly in the blood which fills the proboscis, then they fix themselves by the flagellum at certain points. When fixed they vibrate at first with excessive rapidity, but they soon become quiet; in five minutes they have assumed the herpetomonas phase. No conjugation forms could be detected either before or after the phenomenon.

The multiplication in the proboscis occurs only in 10% of Glossina. It seems more frequent in the young males and females. Are these forms of pathogenic trypanosomes, localised in the proboscis, the only possible infecting agent introduced by the bite of Glossina beyond 24 hours? There seems to be no doubt about this, since in the case of T. Brucei in Glossina palpalis the multiplication takes place only in the proboscis, and, in the case of the other three, multiplication in the alimentary tube has ceased long before that in the proboscis, which is still in full force.

This curious property is absolutely specific to tsetse flies and this explains the peculiar relation between these flies and the spread of disease caused by trypanosomes in Africa. These investigations are fraught with interest and will doubtless form the basis for further study on the lines indicated.*

[1] C. R. Soc. Biologie, LVII, 1904, pp. 615-617.
[2] Do. do. do. do. do.
[3] C. R. de L'Academie des Sciences, T. CXLVI, No. 8, 24th February 1908.

* Whilst this paper is passing through the press an important observation of Kleine has just been confirmed by Bruce, which indicates that trypanosomes undergo a cycle of development in the fly which would then be a true host for this parasite.

Having considered the fate of the trypanosome in the tsetse fly it is necessary next to compare this with its behaviour and growth on artificial media outside the host and pass to the study of

6. *Cultivation of Trypanosomes.*—An important addition to our knowledge of trypanosomes was made by Novy and McNeil.[1] These investigators have succeeded in cultivating outside the body on a special artificial medium in pure culture a number of trypanosomes. By the cultural characteristics they are able to differentiate trypanosomes. This method has given us a means of avoiding the fallacy of "mixed infection" when working out the various problems connected with blood parasites belonging to the protozoa. The observations of so able an investigator as Schaudinn were not free from this fallacy, and his statements with regard to Trypanosoma noctuæ must be regarded with scepticism until they have received confirmation. It is of importance that observations on trypanosomes in insects and in the blood of vertebrates should be controlled by the cultural methods of Novy to insure their freedom from the above fallacy.

Whilst actively growing on the artificial medium, trypanosomes possess a virulence very nearly equal to that of the original blood.

Novy [2] as a result of his cultural investigations considers that trypanosomes do not go through any life cycle in their invertebrate host, *e.g.*, tsetse fly, but only a process of multiplication similar to that in artificial medium. In regard to this view Minchin [3] states that "like some other writers, he (Novy) does not seem to realise the essential distinction between multiplication and development. We can, perhaps, see in this attitude towards the problem the predisposition of an accomplished bacteriologist unaccustomed to think zoologically, if I may use such an expression." He (Novy) expresses the belief that the trypanosomes found in biting insects are harmless parasites of the fly "derived from plant juice, stagnant waters, &c." Minchin[4] states further that "at the present time true trypanosomes are only known to occur in the blood of vertebrates; hence it is reasonable to assume that the insects in question obtain their trypanosomes from the vertebrates. When trypanosomes have been found in plant juices or stagnant waters it will be time enough to speculate on the possibility of blood-sucking insects obtaining them from such sources."

Since this was written an interesting observation has been made by M. M. Edouard Chatton and Eugene Alilaire[5] in the Laboratory of Mesnil. They discovered in a non-biting fly, Drosophila confusca, staeger, a true trypanosome and a herpetomonas. This observation, as the authors point out, would tend to support the view expressed by Novy that the trypanosomes of Arthropods are the original parasites of these animals, and also furnishes evidence to settle the question regarding the identity of trypanosomes and herpetomonas. The work of Roubaud on the cultivation of the trypanosomes in the interior of the proboscis of Glossina also supports the views of Novy, who in the words of Minchin seems to regard the invertebrate host as nothing more, so far as trypanosomes are concerned, than a kind of flying culture tube.

Brumpt, who has made a careful study of the transmission of trypanosomes by leeches, and has studied the evolution of the trypanosome of the eel in the Hemiclepsis marginata, demonstrating that there is normally a hereditary transmission of trypanosomes and trypanoplasms from the adult to the young leech, writes as follows :—" One determines that some hours after their arrival in the stomach of the leeches all the parasites become pyriform and approach closely by the relative situation of the blepharoplast and the nucleus, to the Crithidia of Leger. The flagellum starts from the anterior extremity of the body and persists. A very active segmentation produces an enormous quantity of small parasites, after 48 hours the stomach contains no more Crithidia, they have passed into the intestine where they become elongated into the form of herpetomonas and they continue to live and segment for many months in this form, which is certainly the ancestral form in which these intestinal parasites live before they become blood parasites. After 72 hours one finds true trypanosomes with undulating membrane, which commence to ascend across the stomach and one finds them accumulated in great numbers in the sheath of the proboscis on the 5th day. These forms are inoculated into the eel and rapidly transform by simple elongation into the typical form of Trypanosoma granulosum. The complete evolution of this trypanosome takes place exclusively among the Hemiclepsis."

In July 1907 Brumpt[1] states " that he demonstrated that the normal hereditary transmission of trypanosomes and trypanoplasms amongst the leeches is completely independent of the parasites of a vertebrate host. This demonstrates in a definite fashion that the blood disease of vertebrates is but an accident, but the adaptation of a harmless intestinal parasite of invertebrates."

In addition to studying the cultural characters of trypanosomes a further valuable method of investigating them is to study

7. *The animal reaction of strains of Trypanosomes.*—This consists in the injection of fluids containing trypanosomes into a series of animals and noting whether or not trypanosomes appear in the blood of the animals injected. By this means we can classify the various strains of trypanosome. For example, by this method we were able in Uganda to establish the extremely important fact that the trypanosome found in Glossina palpalis, in the blood of apparently healthy men and the cerebrospinal fluid of cases of Sleeping Sickness were identical.

[1] Journal of Infectious Diseases, Vol. 1, January 2nd, 1904, and November 5th, 1904.
[2] Journal of Infectious Diseases, III, 1906, and *ibid.* IV, 1907.
[3] Quarterly Journal, Microscopical Science, Vol. 52, Pt. 2, 1908.
[4] *Ibid.*
[5] C. R. Soc. de Biologie, T. L. XVI, No. 20, 1908.

[1] C. R. Soc. Biology, 20th July 1907.

The following table shows the results of these observations:—

Animals used for experiment.	Presence or absence of trypanosomes in the blood after inoculation with fluids containing trypanosomes from						
	1	2	3	4	5	6	7
	Sleeping Sickness cases.	Men having no marked signs of Sleeping Sickness.	Fresh flies, Entebbe.	Mr. Porgage's ox.	Jinja cattle.	Abyssinian animal.	Mule, Entebbe.
1. Monkeys—							
a Ceropithecus sp.	+	+	+	−	+	+	+
b. Macacus Rhesus.	+	+	..	..	..	..	..
2. Dogs—							
a. Adult	+	+	+	−	+	+	+
b. Pup	−	−	..	..	..	..	..
3. Jackals	+	+	..	..	..	..	..
4. Cats—							
a. Adult	+	+	..	..	..	..	..
b. Kitten	+	+	..	..	..	..	..
5. Rats	+	+	..	..	+	+	+
6. Rabbits	..	..	..	..	+	..	+
7. Guinea pigs ..	+	+	..	..	+	+	+
8. Sheep	−	−	..	..	+	−	−
9. Goats	−	−	..	..	+	−	−
10. Oxen	−	−	..	..	+	−	−
11. Masai donkey ..	−	−	..	..	+	+	+
12. Dog-faced baboons	−	−	..	..	−	−	−
13. Mule	..	..	..	..	..	..	+

From this table it will be seen that a series of 13 different animals was employed. If columns 1 and 2 be compared it will be seen that the animal reactions are the same in each case, thus establishing the identity of the strain of trypanosome obtained from a man at the time showing no signs of Sleeping Sickness (so called Gambia fever)[1] and a strain derived from a well marked case of the disease. This formed an important link in the chain of evidence by which the causal connection of trypanosome gambiense and Sleeping Sickness was proved. It was held by Plimmer[2] at one time that the trypanosome of so called Gambia fever was distinct from the trypanosome of Sleeping Sickness. He subsequently abandoned this view.

Plimmer states[3] " From the above summary of 211 experiments extending over a period of nearly three years, it will be obvious that the tentative deductions which I made in my preliminary note from the few experiments therein recorded that Gambia fever and Sleeping Sickness are two distinct diseases cannot be maintained." In this view Plimmer is in agreement with the conclusion arrived at by our Commission several years previously.

Further, if column 1 and 2 be compared with 5, 6 and 7 it will be seen that there are distinct differences, and thus we were able to separate the strain of trypanosome derived from the animals in Uganda from that derived from men.

Brumpt[4] has recently described an animal reaction of interest. He finds that if T. gambiense is injected into a garden dormouse during hibernation it becomes infected, but recovers from the infection. He shows, however, that the dormouse has not acquired any immunity towards T. gambiense. He thinks that the disappearance of trypanosomes from the dormouse is due in part to the diminution of vitality of the Trypanosomes under the influence of the lowered temperature and partly to a normal conservation of the physiological functions of the leucocytes. The destruction of the parasites exceeds the reproduction of the parasites at low temperature and hence the animals recover.

[1] Greig and Gray. Sleeping Sickness Report of Royal Society, No. VI.

[2] Proceedings, Royal Society B. Vol. 74, 1904.

[3] Proceedings, Royal Society B. Vol. 79, 1906.

[4] C.R. Soc. de Biologie, T. 64, No. 23, 1908.

Another method of differentiating trypanosomes by animal experiment was introduced by Laveran.[1] The principle of the procedure is the immunising of an animal with a known strain of trypanosome A, and later injecting the immunised animal with a strain X, which it is desired to classify. If after the injection of X strain trypanosomes appear in the blood, then A and X are, probably, different strains of trypanosomes, but if trypanosomes do not appear thus A and X are probably identical.

We used this method, also, in Uganda as a further means of differentiating certain strains of trypanosomes met with.

The following table shows the result of these observations:—

Table showing result of Inoculation of Animals immune to one variety of Trypanosome.

No. of experiments.	Variety of Trypanosome to which animal is immune.	Variety of Trypanosome used for inoculation.	Date of inoculation.	Result of inoculation.	Remarks.
Ox 202 ..	Mule ..	Jinja ..	Nov. 21st, 1903.	Trypanosomes appeared in the blood on the 12th day. Died 20th Jan. 1904.	Rise of temperature after inoculation.
Goat 194 ..	Do. ..	Do. ..	Do. ..	Do.	
Sheep 191 ..	Do. ..	..	Control ..	....	Trypanosomes have never appeared in the blood.
Sheep 211 ..	Abyssinian	Jinja ..	Aug. 23rd 1904.	Trypanosomes appeared in the blood 36 days after inoculation.	Still alive.
Goat 212 ..	Do. ..	Do. ..	Do. ..	Do. ..	Do.
Ox 209 ..	Do. ..	..	Control ..	....	Trypanosomes have never appeared in the blood.

VI. METHODS OF PREVENTION.

As in the case of Malaria there are two broad principles to be recollected in conducting operations for the prevention of diseases disseminated by the tsetse fly:—

(*a*) Operations directed against the fly.

[1] Greig and Gray: Sleeping Sickness Report of Royal Society No. VI.

(*b*) Operations directed against the parasite which the fly transmits.

Practical preventive measures are framed with the object of attacking the problem along both lines. It would be a "Council of perfection" to recommend the complete destruction of all flies or of all the parasites in the vertebrate host.

In regard to the prevention of the spread of Sleeping Sickness the above principles may be applied practically in the following directions :—

I. Operations directed against the fly.

(1) Destruction of the pupæ of the fly—

(*a*) *By clearing of undergrowth*—particularly near towns, encampments, fords, &c., in fact, wherever human beings are brought together in numbers. The clearing is best effected by burning. The heat generated by the fire, and the exposure of the area to the full effects of the sun's rays by removing the shady undergrowth, render the district unsuitable for the fly by raising the temperature above the point favourable to the development of the nymphæ. So in time the fly will die out of these "cleared areas". The fly does not exist apparently in hot dry countries, *e.g.*, Egypt[1], and India, probably owing to the fact that the nymphæ cannot develop under conditions found in these countries.

(*b*) *Destruction of the food-stuff of the Fly.*—The fly as we have seen lives almost exclusively on blood, hence if deprived of this source of food supply a diminution of their numbers, in the first instance, and, ultimately, a complete eradication might be expected. If the views of Koch be correct the problem is further simplified, because as, we have seen, he is of opinion that the crocodile is the chief source of supply of blood for the tsetse fly and he has accordingly recommended the wholesale destruction of these animals.

A fresh Commission under Sir David Bruce, F.R.S.[2], is working in Uganda, and one of the problems which will engage the attention of this Commission is the proposition that the blood of the crocodile is the main source of food supply of the tsetse fly. The Report of this Commission will be awaited with interest.

(2) *Destruction of the Fly by other animals which will prey on it.*—This might possibly be a practical line of attack. Certain kinds of fish have been employed to destroy the larvæ of mosquitoes. The cultivation of some plant might be found whose odour would be obnoxious to the fly.

As the investigations progress other lines of attack on the fly will probably suggest themselves.

II. Operations directed against the parasite which the fly transmits.

It is obvious if we can devise means for preventing the fly from becoming infected by the Trypanosoma gambiense it will cease to be a disseminator of Sleeping Sickness. In the case of animals infected by trypanosomes the problem is comparatively simple and consists in the slaughter of such animals as are found harbouring the parasite and in this way the disease is stamped out gradually. In the case of man a means has to be discovered by which it will be possible to completely destroy all the trypanosomes without damaging seriously the host. This problem has not yet been solved, but it is engaging the serious attention of a number of investigators.

We will consider :—

Destruction of Trypanosomes in the vertebrate host by drugs.

(*a*) *Arsenic.*—This drug has been extensively used by various investigators from Livingstone onwards.

The following table from the Report of the Sleeping Sickness Commission[1] shows the effects of arsenic on Trypanosoma gambiense.

Name and Number of case.	Month observations were made, 1904.	Trypanosomes in the lymph glands.		Trypanosomes in the blood.		Amount of arsenic administered as sod. arsenic.
		No. of observations.	Results.	No. of observations.	Results.	
Tenwa, 302 ..	June ..	3	3+	4	2+ 2—	As nil.
	July ..	11	3+ 8—	9	1+ 8—	As 103 mgs.
	August ..	..	..	11	2+ 9—	As 20 mgs.
	September ..	..	..	8	8—	As nil.
	October ..	..	..	6	6—	Do.
Kitsame, 303 ..	June ..	9	9+	23	16+ 7—	As 74 mgs.
	July ..	15	13—	15	2+ 13—	As 100 mgs.
	August ..	..	..	12	3+ 9—	As nil.
	September ..	..	..	9	2+ 7—	Do.
	October ..	..	..	6	6—	Do.
Manawa, 304 ..	June ..	1	1+	1	1—	Do.
	July ..	8	4+ 4—	6	6—	As 105 mgs.
	August ..	2	1+ 1—	11	3+ 8—	As nil.
	September ..	1	1—	9	1+ 8—	Do.
	October ..	..	..	9	1+ 8—	Do.
Mondu, 310 ..	July ..	5	3+ 2—	4	1+ 3—	As 85 mgs.
	August ..	3	3—	11	2+ 7—	As nil.
	September ..	1	1—	9	9—	Do.
	October ..	..	..	6	1+ 5—	Do.

The conclusion we arrived at was "that the action of arsenic in vita on the Trypanosoma gambiense is partial. It destroys a number of trypanosomes, and, probably, these act as immunising agents. Its administration in the stage of polyadenitis tends to help the natural resistance to combat the disease."

(*b*) *Atoxyl* is a combination of arsenic and an aniline preparation. It was first used in the treatment of trypanosomiasis by the workers of the Liverpool School (Thomas and Breinl). It was afterwards extensively employed by Koch in Uganda, and, from

[1] Greig : Report No. VI, p. 273, Sleeping Sickness Commission of Royal Society.

[2] British Medical Journal, July 4th, 1908.

[1] Greig and Gray : Report No. VI of Sleeping Sickness Commission of the Royal Society, p. 68.

results obtained, he formed a very favourable opinion of its action in destroying trypanosomes. In connection with the administration of atoxyl to animals infected with trypanosomes, a fact of great scientific and practical interest was first brought out by Ehrlich.[1] He showed that it was possible by the injection of atoxyl into animals infected with trypanosomes to obtain strains of trypanosomes which were "resistant" to atoxyl; that is to say, the further injection of the drug had no effect on the parasites and that this property was retained by the trypanosomes after numerous passages through mice. Scientifically, it is a discovery of much interest, because we have here a definitely acquired property, "atoxyl tolerance," handed on from one generation to another. This discovery opens up a very wide field for investigation. Practically, also, it is a discovery, of considerable importance, because if the strain of trypanosome be once rendered "atoxyl tolerant," all subsequent efforts to destroy it with atoxyl will be fruitless. Hence the administration of atoxyl in cases of human trypanosomiasis should be carefully controlled.[2]

(*c*) *Antimony Compounds.*—Plimmer and Thomson[3] have investigated the action of a large number of drugs on trypanosomes, and they find that Sodium Antimonyl Tartrate gives the best results. They state: "This substance (Sodium Antimonyl Tartrate) in 1 per cent. solution is that which of all the various bodies mentioned in these papers, including atoxyl, has the most marked and remarkable influence upon trypanosomes in the living body."

(*d*) *Aniline Dyes.*—A great variety of these have been employed in the attempt to destroy trypanosomes in the living body by Ehrlich, Mesnil and others.

The whole subject of the treatment of trypanosomiasis by drugs is being considered by a Committee of the Royal Society.[4] The Report of this Committee will be looked forward to with much interest.

Until a means of destroying the trypanosomes in the vertebrate host has been found, it is necessary for us to fall back on measures which aim at preventing the association of the harbourer of the parasite and the tsetse fly. In addition to those already referred to, *e.g.*, clearing of forest, &c., these measures include:—

I. *Isolation Camps.*—These camps are situated in selected "fly free areas," and receive the more advanced cases of Sleeping Sickness from the "Fly Areas." Every case of trypanosomiasis which is removed from the fly area removes one source of infection for the fly. In these camps the patients are maintained and treated with drugs which have proved efficacious.

II. *Detection of all harbourers of the trypanosome and prevention of their movement into "clean fly areas"*.—As will be readily understood, this is one of the most important methods of checking the spread of Sleeping Sickness; but, in order to put it into practice, it is absolutely essential that we should have a practical and certain means of detecting the harbourers of the parasite even in the initial stages of the malady. Fortunately, the exact recognition of early cases of Sleeping Sickness has now been rendered easy and certain by the method of gland puncture.[1] The juice of the enlarged glands of cases of Sleeping Sickness, especially the posterior cervical, shows many actively motile trypanosomes. Some of the juice can be obtained readily by puncturing a superficial gland in the posterior triangle of the neck with a hypodermic needle. The fluid is examined under a low power, 150 to 200 diameters, when the actively motile trypanosomes can be readily detected. In practice, the posterior cervical glands should be palpated, and, if found to be enlarged, the traveller should be further examined by gland puncture to determine the presence or absence of trypanosomes in the gland juice. If the trypanosomes are found to be present, the person should not be allowed to enter a tsetse fly belt.

It is obvious that the prevention of the spread of Sleeping Sickness in Africa largely turns on the detection of the harbourer of the parasite, and hence the great importance of possessing a certain and ready method of doing so.

The method of diagnosis by gland puncture was tested later in the Congo by Dutton and Todd[2] who confirmed our results. Koch[3] who investigated Sleeping Sickness in Africa states: "For the purpose of diagnosis of Trypanosomiasis, 163 gland punctures have been performed up to 1st October, and trypanosomes found 160 times. This result, therefore, furnishes a complete confirmation of the statements of the English investigators, Greig and Gray, who discovered this method of diagnosis, and strongly recommended it. As the result of their investigations, they come to the conclusion that in a district where Sleeping Sickness was prevalent the occurrence of swollen glands in the neck was an almost undoubted sign of the disease. With this our observations are throughout in agreement in that we have been able to prove the presence of trypanosomes not only in the enlarged glands of persons appearing with the disease, but more frequently, also, in such as were apparently healthy, and still went to their work."

Kinghorn and Montgomery[4] have recently published the results of their investigations on the incidence and prophylaxis of Human Trypanosomiasis in North Eastern Rhodesia. They state: "Since Greig and Gray noted that trypanosomes were fairly constantly present in the enlarged glands of persons suffering from trypanosomiasis, the efficiency of this means of diagnosing the disease in its earlier stages has been repeatedly demonstrated," and they add, "that Dutton and Todd were the first to recognise the practical importance." In this connection I would direct attention to the following paragraph, p. 8, of Report No. VI of the Sleeping Sick-

[1] Berliner Klin. Woch., 1907, No. 9, bio. 12.
[2] Deutsh. Med. Woch., No. 27, July 2nd, 1908.
[3] Proceedings, Royal Society, No. B. 536, February 4th, 1908.
[4] Proceedings, Royal Society, No. B. 535, February 4th, 1908.

[1] Greig and Gray, Proceedings of Royal Society, Vol. L.XXIII p. 455, 1904.
[2] Memoir 16, Liverpool School of Tropical Medicine.
[3] Sonderb-ilege Deutsche Med. Woch., No. 51, 1906.
[4] Annals of Trop. Med. and Parasitology Series, T. M., Vol. II., No. 2, June, 1908.

ness Commission of the Royal Society (Greig and Gray), referring to the method of gland puncture :—

"A practical outcome of these observations will be that the recognition of Sleeping Sickness in its earliest stages will be a matter of easy accomplishment; the enlargement of the superficial glands presents a sign which will arrest the attention of the observer, and the determination, by the above method, of the presence of trypanosomes in them can be very simply carried out."

From this it will be seen that *Dutton and Todd were not the first to recognise, but the first to confirm the practical importance of gland puncture*, as a means of diagnosing human trypanosomiasis in its earliest stages.

Kinghorn and Montgomery[1] also state "As compared with other means of detecting the disease it is infinitely the best." Further[2] "The whole system of prophylaxis is based on the application of palpation and gland puncture." Mon. A. Broden, Director of the Laboratory, Leopoldville, Congo, and Rodhain[3] state "As we have stated in previous publications we consider that the puncture of the glands, especially the glands of the neck, is the most rapid and practical means of diagnosing human trypanosomiasis."

Todd[4] states "The evidence proving that the examination of gland juice, first used by Greig and Gray, is the most constantly efficacious of all methods of demonstrating the presence of trypanosomes in the infected is incontrovertible."

Even with the most rigorous inspection a certain number of cases will slip through, but nevertheless every case prevented from entering a "clean area" diminishes the chances of infection of the tsetse fly by removing a "carrier" of the virus.

III. Accurate charting out of the distribution of Sleeping Sickness and Glossina Palpalis.

This is a measure of obvious importance and it is being undertaken by a recently established Bureau of Sleeping Sickness in London. In time maps of the whole of Africa showing the exact distribution of the Sleeping Sickness and Glossina will be available.

The Societé de Pathologie Exotique[5] have proposed certain measures to be adopted in the French Colonies. The measures are contained in 16 paragraphs; and indicate how the known scientific facts may be put into practice in the struggle against the disease.

IV. To induce the inhabitants as far as possible to live outside the "Fly area."

In connection with this the following resolution was adopted by the Societé Pathologie Exotique."[6] "That the Administration take measures to favour the raising of certain animals, such as, the country pigs, the goat, or the fowl, or the cultivation of crops to replace fish as a food." The idea being to offer the inhabitants of the districts near the lakes and rivers, where the tsetse fly is prevalent, some compensation for the loss of the fishing incurred by their leaving the riverine district. In time the districts which are now dangerous to inhabit will become habitable again for the reason that the fly, not having an infected population to feed on, will become free from the virus and so be reduced to a harmless condition, as far as the propagation of disease is concerned.

V. The Choice of Site for Buildings.

At the present time the authorities are fully alive to the importance of selecting sites for stations in a fly-free area. Previous to the work of the Commission in Uganda, what appeared to be a very favourable site for the Administrative capital of Uganda, Entebbe, was selected. It was close to the Lake. During the researches of the Commission the Botanic Gardens, Entebbe, furnished us with many specimens of Glossina palpalis. On account of the presence of the tsetse fly the question of the removal of the station from Entebbe to a "fly-free area" was considered. However, extensive clearing operations were undertaken with the object of eradicating the tsetse fly from Entebbe. In selecting sites for stations in the future in Sleeping Sickness districts the question of the presence of tsetse flies will always require to receive most careful attention.

In this paper only the broad principles of prevention of the spread of Sleeping Sickness have been sketched, and, as regards the problem of the practical application, each locality will require to be dealt with on its own merits.

As regards personal protection, those going to countries where tsetse flies and Sleeping Sickness occur should acquaint themselves with the knowledge which recent scientific investigation has placed in their hands, and rigorously follow out the indications. Before the nature and mode of spread of Sleeping Sickness had been accurately determined, persons living, even for a day, in districts in which the disease occurred ran great risks. Now with suitable precautions these risks can be obviated and this is the direct result of the scientific investigation.

DISCUSSION.

Mr. F. M. Howlett advocated research by Indian Veterinary Surgeons upon the causes of surra on the lines of Capt. Greig's paper. It had been found for certain that the genus Hæmatopota (Tabanidæ) was a transmitter of surra. He suspected that other biting flies might also carry infection, but at present no work of investigation had been started.

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[1] Annals of Tropical Med. & Parasitology Series, T. M., Vol. II, No. 2, June, 1908.

[2] Do. do. do. do. do. do.

[3] Archiv für Schiffs and Tropen Hygiene, Heft 14, Bd. XII, 1908.

[4] British Medical Journal, October 10th, 1908, p. 1061.

[5] Bulls. Soc. Path. Exotique, 10th June, 1908.

[6] Bulls. Soc. Path. Exotique, 10th June, 1908.

THE ROLE PLAYED BY TICKS AND BITING FLIES IN THE TRANSMISSION OF VARIOUS DISEASES TO MAMMALIA.

By Captain R. M. CARTER, I.M.S.,

Officiating Director, Pasteur Institute of India.

The role played by ticks, biting flies and other blood sucking parasites in the transmission of various diseases to mammalia is one of economic importance. These seemingly insignificant pests play a constant part in the life history of the world, and the civilization of unknown lands, far greater than that played by recognised factors of occasional importance such as war and famine. The malarial mosquito, a constant scourge of tropical and semi-tropical countries, has been shown to be a factor in the life history of great nations. As a disease malaria became endemic during the period of the decline of Greece and Rome. The plague flea has taken its toll of millions from the human race. Africa, the greatest of all the continents, lies under the ban of trypanosome transmitting biting flies such as the tsetses. Over half a million human beings have died during the last ten years from fly-borne sleeping sickness, whilst examination of a large number of villages by competent observers has shown that 30 to 50 per cent. of the inhabitants in these infected areas must sooner or later succumb to this disease. The opening up of vast fertile tracts of Africa is checked by the fly-borne scourges of cattle and domestic animals. Thus it will be seen that these invertebrate parasites affect the economics of the present and succeeding generations profoundly.

Civilization, with yearly increasing facilities for human traffic and intercourse in and between tropical countries, is in spite of human precautions, disseminating diseases through races, human and animal, where they were previously unknown. The spread of these diseases, such as sleeping sickness, has only just awakened civilization to a proportionate recognition of their gravity. The fundamental discoveries on the modes of infection of mammalia, through the agency of invertebrate hosts, necessitates a comprehensive knowledge of the biology, bionomics and structure of biting flies, ticks, etc. Without this, the etiology of the many varieties of protozoal infections they transmit is incomplete.

Ticks of various species are recognised factors in the propagation of piroplasmal and spirochætal diseases. It is probable further investigation will prove them associated with others as yet unrecognised. Our knowledge of this class of parasite is most imperfect, by reason of the vast number of species that exist. Most ticks present marked differences in their morphology at its several stages, hence the value of expert knowledge on this class. Further, the parasitic cycle of pathogenic protozoa within these insects, is intricate and puzzling, the morphology assumed by the parasites within the tick being almost unknown.

Ticks will be dealt with first. By these insects, man is infected with Spirochæta Duttoni and S. Rossii (Human relapsing fevers). They also infect horses with S. equi, cattle with S. Theileri, sheep with S. ovi. Horses, cattle, sheep, goats, and dogs are similarly infected with varieties of piroplasma.

Ticks as a class of ectoparasites are most abundant in warm countries. This is due to the fact that cold is unfavourable to the requirements of the egg, and early stages in their life history. They attack all types of terrestrial vertebrates, most mammalia, and aves, some reptilia and amphibia.

They live an obligatory transitory erratic parasitism, and, once safely through the earlier stages of their existence, possess a remarkable vital resistance. Argas Persicus have been known to live unfed for three years, A. reflexus for six years in a corked bottle, Ornithodorus megnini unfed for two years and O. moubata for two years. Their life cycle is prolonged when food is scarce and shortened when it is plentiful. This is a curious adaptibility to adverse conditions and one of importance in the spread of disease.

There is no constant correspondence between the species of host and that of these parasites. Excepting the mature female who alone shows a mild specific preference, the males, larvæ, and nymphæ may be considered free parasites for most vertebrates.

World wide dispersion of these parasites by the more common vertebrate hosts in the service of man is the result.

As types of ticks, disseminated by civilization, we may take Ixodes ricinus, Hyalomma aegyptium and Rhipicephalus annulatus. The habits of ticks vary roughly according to their classes. Ixodes thrive best as a rule in temperate climates, Aponomma in hot countries. Hæmaphysales are chiefly Asian ticks, Rhipicephalus and Hyalomma mainly African. Amblyomma are found mostly in South Africa, whilst Dermacentor is a world wide genus in its distribution.

I propose to deal with the classification of ticks and their life history with extreme brevity. The latter is of special importance as without a general

knowledge of it, the parasitic life cycle of the pathogenic protozoa they transmit cannot be followed.

All ticks belong to a super-family Ixodoidea. This is subdivided into two great sub-families Argasidæ and Ixodidæ. Rhipicephalinæ are sometimes subdivided from the latter as a third subfamily.

Argasidæ are known by the following main characteristics: (1) they have no scutum or ventral shield; (2) the capitulum or mouth parts of the adult is not prominent when seen from above; (3) the tarsi are not pulvillated; (4) their stigmal plates lie between the third and fourth coxæ; (5) sexual dimorphism is slight. Ixodidæ on the other hand present: (1) a scutum; (2) prominent capitulum; (3) pulvillated tarsi; (4) their stigmal plates behind the fourth coxa; (5) pronounced sexual dimorphism.

Argasidæ are sub-divided into:—

Genus 1. Caris.
2. Argas.
3. Alectorobius.
4. Ornithodorus.

Ixodidæ are sub-divided into:—

Genus 1. Ceratixodes.
2. Eschatocephalus.
3. Ixodes.

Sub-family Rhipicephalinæ:—

Genus 1. Aponomma.
2. { Hyalomma. / Amblyomma.
3. Hæmaphysalis.
4. Dermacentor.
5. Margaropus.
6. Rhipicephalus

The life history of a tick is as follows:—The eggs are gelatinous ovoids usually less than 1m. in length. Pale when first laid, they darken as they grow older. As they mature, reticulation appears beneath their membranous surface, and a dark spot appears. Just before hatching, the embryo can be seen making a slit at one end of the egg, through which it emerges as the larva.

The larva presents six legs, has no sexual organs or spiracular orifices. After a short period of rest beside the shell, the larvæ seek food. They swarm up to the tips of the blades of grass and await in clusters their warm blooded host as it passes. They feed on the host and then drop off gorged with blood. A short period of quiescence is spent on the ground, during which each larva undergoes ecdysis, splits its skin at the sides, and emerges from what is known as the "first moult," as a nymph. The nymph presents eight legs but still no sexual organs, or spiracular orifices. As before, the parasite seeks food from a warm blooded host, then drops off to moult again. If it belongs to the Ixodidæ, it emerges on ecdysis, as an adult, but if it belongs to the Argasidæ, a variable number of alternating feeds, and moults, takes place before it becomes the sexually mature adult. It is worthy of note that O. megnini is unique amongst Ixodoidea, feeding but once in its life as a nymph. Some ticks require but one host, all moults taking place upon the surface of the host's body. As examples of these we have Rhipicephalus annulatus, R. decolouratus. Other ticks require two hosts. These feed and moult on one host, until they become nymphs. They then feed, drop off, undergo ecdysis, and seek another host upon which to complete their life cycle. An example of such ticks is Rhipicephalus evertsi. In ticks requiring three hosts, all moults are effected on the ground, for example R. appendiculatus. As types of ticks requiring a number of hosts we may take Ornithodorous moubata and Argas persicus.

The following is the way ticks feed:—The insect securely fixes itself in position by means of its clawed limbs. The capitulum is applied against the skin. The rostrum is then depressed, and the toothed mandibles and hypostome are driven into the skin in a boring manner. The mandibles are then separated to allow the hypostome to be driven more deeply into the wound, where it is automatically held in position by the rows of large retrograde teeth on its surface. The insect then sucks the blood as it wells up, every now and then rotating the mandibles and hypostome as the supply wanes. The body of the parasite slowly fills. Its creased surface, when unfed, changes to that of a tight smooth bag. Every now and then a few drops of clear fluid filtered from the ingested blood is voided per anum, and a whitish secretion exudes from the Malpighian tubes.

The pain from the bite is due to the acid salivary secretion poured into the wound along the salivary ducts, and is very severe in cases of bites from some ticks such as A. Persicus. A copper ro-seala around the site of the bite, may be seen in human beings lasting for weeks.

The question of coition and ovulation in ticks is outside the intention of this paper.

Having briefly discussed the life history of ticks as a class it now remains to deal with those that directly transmit diseases to mammalia.

Ornithodorus moubata, in so far as it is distinct from O. savignyi, is a purely African tick, extending from Leopoldville to Zanzibar. It is extremely abundant in the Congo Free State, and along African trade routes. This tick transmits S. Duttoni and S. Rossii, the causal agents of African relapsing fever, to man. It will feed on pigs, sheep, goats, dogs and monkeys, but it almost exclusively feeds on man, and in its habits resembles the bed bug. It is only to be found in dry spots, and hides after feeding. This tick once infected with S. Duttoni, is capable of transmitting these parasites to the batches of eggs laid after each feed. The progeny from these infected eggs, on arrival at maturity, lay batches of similarly infected ova. The final broods, as well as the two

preceding generations from which they were derived, are capable of infecting man and monkeys in all stages from the larva to the adult. In addition to the above species, this genus includes ten established species, savignyi, turicata, talaje, pavimentosus, megnini, coriaceus, erraticus, tholozani, lahorensis, percosus. Doubtful species are morbillosus, canestrini, papillipes.

Rhipicephalus, or Boophilus annulatus, is a common tick in the southern portion of the United States. Its hosts are cattle and deer. This tick transmits the disease commonly known as "Texas Fever" or "Red Water" in cattle, due to the Piroplasma bovis or "bigeminum." The cycle of these protozoa within the tick is interesting, for the tick can only transmit the disease whilst in the larval stage.

Rhipicephalus bovis Australis, is a sub-variety of R. annulatus, and differs from the latter by having an additional tooth on the dentate process of the mandible. It also transmits Piroplasma bovis.

Ixodes ricini, Synomyms, I hexagonus, I reduvius, is commonly known as the "Castor bean tick" in America. It is also found in Europe, and is a carrier of Piroplasma bovis. In addition to this disease this tick was supposed to transmit "Louping ill" in sheep. Wheeler of the "Louping ill" Commission, proved that this is a bacillary and not a protozoal disease; further this tick does not carry the infection.

Rhipicephalus appendiculatus or "Brown tick", also known as the "African coast fever tick", is a carrier of Piroplasma parva Theileri. This tick requires three distinct hosts and feeds on cattle and horses in Cape Colony. The cycle of the Piroplasma in this tick is most intricate. Lounsbury has definitely proved that R. appendiculatus cannot transmit P. parvum as adult or larva from one animal to another. Infected nymphs, taken off sick animals, will only transmit the disease when they become adults. Similarly infected larvæ will only transmit when they become nymphs. Other ticks incriminated in the spread of this disease are Rhipicephalus evertsi, and R. simus.

Amblvomma Hebraeum commonly called the "Bont tick" of S. Africa. This is a beautifully marked insect. The male has a body with black markings on a gold and green ground. The present distribution of this tick is S. Africa, but observers note it is spreading north with civilisation. The hosts for this tick are sheep and goats only. To these it transmits the disease known as "Heart water" in S. Africa, due to Piroplasma ovis.

Hæmophysalis leachii, commonly called the S. African "dog tick" is the carrier of Piroplasma canis. When this host is acutely attacked by these protozoa it suffers from what is known as "black water fever" in dogs. Chronic cases are known as "malignant jaundice" in dogs. The cycle of Piroplasma canis within the tick is highly intricate and interesting. The adult mature daughter tick alone can produce infection. This will be shown as follows:—

H. leachii feeds on an infected dog, drops off and lays a batch of eggs. The Hexapod larva on hatching seeks out a healthy dog which is not infected by the bite. The insect drops off gorged, moults, and, as an octopod nymph, attacks another healthy dog. This dog is not infected by the bite. The insect once more drops off and moults, becoming adult. In this final stage its bite will infect a healthy dog with the disease.

Rhipicephalus bursa is a tick found in Europe, Africa, and the West Indies; this insect transmits Piroplasma ovis known in Europe as "Carceag" "Roumanian piroplasma," "Malignant jaundice" in the sheep."

The cycle of the protozoal parasite within the tick is as follows:—The adult tick feeds on an infected sheep, drops off, and lays a batch of eggs. Larvæ from these eggs feed on uninfected sheep but do not infect them. They drop off and moult, and on becoming nymphs feed on clean animals without infecting them. On reaching maturity after their final moult upon the ground, the adult infects sheep on feeding.

There is a very similar variety of this tick in America known as Rh. bursa var Americana.

Argas Persicus popularly known as the "Persian bug," "Persian tick," "Miana bug," "Garib Guez," "Wandluis," "Tampan," "Adobe tick," attacks man, the fowl, duck, goose, turkey and wild dove, and occurs commonly in N. E. and N. W. Persia. It is a widely distributed species being found in N. and S. Africa together with a similar species known as Argas Americanus. It also occurs in all five Australian colonies, N. and S. America. A very large variety of Argas, A. reflexus, is found near Paris; this species is a common parasite on European pigeons especially in the Ardennes. A. persicus transmits S. Marchouxi (gallinarum) to fowls, ducks and geese, and is capable of doing so for six months after infection. The fertility of this species is very remarkable. A fertilized female will lay for over three years after feeding. The resistance to adverse conditions, shown by the larvæ, is marked, as, on hatching, they can exist without food unharmed for three weeks. Other established species of Argas are, transgariepinus, brumpti, æqualis, vespertilionis. There are four doubtful species, brevipes, transversa, hermanni, cucumerinus. The following are some of the ticks found in India and neighbouring countries:—The Indian group is incomplete as I could not obtain a full list of Asian ticks from the Natural History Museum, Calcutta, their collection being at present in the hands of specialists at home. In spite of this, however, the lists will, no doubt, assist in the identification of such species as may

be met with by those interested in this class of parasite.

As a detailed description of the mouth parts of pathogenic ticks would add greatly to the length of this paper, I propose to illustrate these by diagrams and insect specimens; these will include the more common types of pathogenic ticks met with in the tropics.

Ticks found in India and Neighbouring Countries.

	1 Ornithodorus.	2 Argas.	3 Hyalomma.	4 Hæmaphysalis.	5 Rhipicephalus.	6 Ixodes.	7 Aponomma.	8 Amblyomma.	9 Dermacentor.
India ...	O savignyi. O savignyi var (Cæca). O erraticus. O lahorensis.	A persicus. A vespertilionis.	H ægyptium.	H spinigera. H bispinosa. H semermis (Bengal). H flava. H fusca.	R sanguineus. R annulatus. R bursa.	I fuscolineatus. I holocylus. I acutitarsus I brevipes (Ceylon).	A gervaisi. A latum.	A indum. A testudinarium. A nausificum A bengalensis(Bengal). A integrum. A distinctum	D compactus D indicus.
Burma ...				H asiatica. H birmaniæ. H canestrini. H gestroi. H histricis.	R bhamensis. R javanensis. R ruber. R flavus. R haemaphysaloides.	I birmanensis. I bengalensis I globulosus. I granulatus.	A gervaisi. A testudinis.		D auratus. D indicus. D longipes. D foai.
Asia Minor, Syria and Judea.		A persicus.	H ægyptium. H syriacum.	H punctata. H cornigera. H spinigera.		I ricinus.			D parvus.
Arabia ...	O savignyi. O savignyi. var cæca.		H ægyptium.		R sanguineus.				
Persia ... Bukhara ...	O canestrinii O tholozani.	A persicus. A tholozani.	H ægyptium.		R sanguineus.				D reticulatus. D reticulatus var niveus.
Caucasus ...	O canestrinii O tholozani.	A persicus.	H flava. H inermis		R annulatus.	I ricinus.			D reticulatus. D reticulatus var niveus.
Cochin-China and Annam.			H syriacum.	H hirudo.				A testudinarum.	
Malay States.				H punctata.	R sanguineus. R sanguineus var Australia.			A extraoculatum.	
Siam ...								A sublæve.	
Japan ... China ...		A persicus.	H ægyptium.	H bispinosa. H flava. H hirudo. H punctata.	R sanguineus. R paulopunctus. R annulatus var caudatus	I ovatus. I parvirostris I acutitarsus.		A arteriosum. A sublæve.	D reticulatus.

All research upon Trypanosome fly-borne diseases having for its object curative or preventive measures is based upon a knowledge of—

(1) The method of transmission of the parasites, whether carried by one or more of the following genera of biting flies, Glossina or Tsetse flies, Tabanidæ or horse flies, Hæmatopota or blind flies, Stomoxys or stinging flies, Lyperosia, and Hippoboscidæ.

(2) The life history structure of the various vectors of each disease.

(3) The incidence and effects of trypanosoma in wild game and domestic animals.

(4) The varietal characters of the various pathogenic trypanosoma and their reaction to selected drugs. The first three sections alone come under the scope of this paper.

The genus Glossina, "tsetse flies," is intimately connected with the study of African trypanosamiases. Their morphology, biology, and taxonomy, are thus a matter of importance.

Tsetses may briefly be described as flies of harm-

less appearance, a little larger than the house fly, Musca domestica, but much larger than Stomoxys calcitrans. The common characteristics of the nine species are as follows.

Narrow bodied elongated flies, 6·5—7·75m. long. They are usually of a greyish brown or yellowish brown colour. When a Glossina is seen at rest, its wings are closed flat, the one over the other, thus differing from Stomoxys and Hæmatopota, whose wings at rest are separated. The biting apparatus consists briefly of a labium, labrum and hypopharynx forming the proboscis. This is ensheathed in the palpi, thus differing from Stomoxys, and in length is equal to that of the thorax minus the scutellum. Further this proboscis projects horizontally in front of the head, and is expanded at its base into an onion shaped bulb.

The wings of both sexes present the fourth vein curved in the mid region. This is one of the main diagnostic points between all tsetse flies and other biting flies.

The male presents a genital protruberance at the distal end of the ventral surface called the hypogium, this latter is absent in the female. Glossina are divided into nine species: G. palpalis: G. pallipides, G. pallicera, G. longipalpis, G. fusca, G. morsitans, G. tachinoides, G. tach Westwoodii, G. maculata. All these are confined in their distribution as far as we know to Africa save G. tachinoides which has been recently discovered in S. Arabia. It is quite probable that though unrecognised, some species of tsetse fly may be sparsely scattered through other neighbouring tropical countries.

Glossina differ from the majority of Diptera in that they do not lay eggs, but extrude a yellowish larva, almost as large as the abdomen of the mother. This larva on extrusion crawls to a suitable hiding place, such as the roots of a banana tree besides a lake. There it turns black and becomes the pupa from which emerges later the adult fly. The habits of Glossina, as I am about to show, vary markedly, and upon these depend greatly the spread, and our proposed methods of control of certain trypanosome infections. All Glossina must be regarded with suspicion, as possible factors in the spread of T. gambiense, and increased knowledge of their life histories is necessary.

G. palpalis, the chief transmitter of human sleeping sickness, is a lake and river border fly. It requires tree shade, being usually absent where a stretch of water is bordered alone by grassland. Both sexes of this fly, like other tsetses, are voracious blood suckers, biting most furiously as the sun approaches its zenith, though they have been known on moonlight nights to bite human beings. G. fusca, the tsetse, also incriminated in the spread of T. gambiense, is probably a lover of water and shady banks, but the habits of this species still require close observation.

G. morsitans, the transmitter of T. Brucei, T. vivax, and T. dimorphon, in animals, is a fly that has no particular predilection for water or shade. Hence the fact that it is widely scattered through certain sparse tracts of virgin bush in Africa. It is also a voracious feeder about midday.

Two views are held on the mode of transmission of pathogenic trypanosomes by tsetse and other biting flies. The one is that the tsetse transmits these parasites in an unaltered condition from an infected to another infected host—a mechanical transmission by contamination. The other, or developmental view, is that the fly ingests its trypanosoma on feeding on an infected host, and that developmental changes in these parasites take place within the infected fly. A special form suitable for inoculation into a clean host is then injected by the fly, after a short period, and during the act of blood sucking. The whole subject is rendered more difficult by the fact that many tsetse flies, contain non-pathogenic trypanosoma, such as **T. Tullochi**, **T.** Grayi which have been found in some districts relatively in 1·7 per cent. and 1·47 per cent. of all fresh flies examined. Again a trypanosome within a non-blood sucking fly has recently been described from France. Recent work in Africa, however, on the whole, shows that mechanical transmission of trypanosome infections is probably the only method.

The life history of T. gambiense, the trypanosome of human sleeping sickness within G. palpalis, is interesting. On ingestion, these trypanosoma are found in the mid gut of the fly, not in the proventriculus, or rectum, where fresh fly trypanosoma occur. If the fly is examined 24 hours after infection, slight increase in the parasites is noticeable, dividing forms being present. After 48 hours the trypanosoma are still numerous, but parasites with different forms are appearing. After 72 hours, the parasites are difficult to find, and, after 96 hours, no typical trypanosoma are present. From these observations, we conclude that the parasites either die out in the fly in three days, or assume an unrecognised form, part of their life cycle, a protective measure within the infected insect. The incubation period of human sleeping sickness is variable, from a few months to as long as 8 years. To recognise the importance of this fly-borne disease upon the future of Africa it is as well to note a few facts. Over half a million human beings have died in Africa during the last 10 years. Between 1901 and 1906, 100,000 victims at least have died in Uganda alone. Of 300,000 inhabitants around the Victoria Nyanza 200,000 persons have been swept out of existence. The valleys of Senegal, the Niger, Congo, Upper Nile, and the huge rivers lying between them, are infested with tsetse and other biting flies. Undeveloped human sleeping sickness has been found in 30 to 50 per cent. of the population of many villages in infected areas that have been examined systematically. Most of these persons

must succumb to the disease, and during their remaining life span act as reservoirs, whence tsetse and other flies draw their virus to further spread the disease. At present along the main trade routes in these regions, trading caravans, bands of miners, porters, labourers and soldiery traffic or journey in the interests of civilisation; many of these become themselves infected in infected districts, and later in the course of their journeying infect the biting flies, and, thus, the inhabitants of uninfected areas.

The spread of this scourge is probably far more serious and widely extended now than the small bands of highly scientific workers such as Bruce, Greig, Nabarro, Dutton, showed in past years. Those occupied in special research to-day in Africa, have to face extensions from infected foci which are rapidly progressive, and far spreading along fresh lines of human traffic. This is a progressive age even in Africa, and yearly increasing facilities for commerce and travel lead to further expansion of infected areas, and the sowing far from its site of origin of a fatal disease, whose presence is for a long time unsuspected, and masked by its long latent period.

The main biting-fly borne trypanosoma, affecting animals, are T. Brucei, T. vivax, T. dimorphon, T. Evansi, T. equinum, T. Theileri, T. transvaliensis.

In nearly every country, that presents pathogenic trypanosome infections of animals, we find (1) biting flies, (2) one or more species of animals that is immune to the presence of, or remains resistent for a long period to, certain species of trypanosoma. These immune, or long resistent animals, act as reservoirs or carriers from which other susceptible animals are infected by the bite of domestic or other blood sucking flies. As examples of animal trypanosome carriers, we find the Indian camel, who will act as a carrier for surra up to 2 or 3 years. Horses in Sind, and other parts of India are thus infected by the agency of biting flies.

Cattle in S. America are similarly trypanosome carriers for susceptible imported horses.

Another method of infection it is as well to refer to here; this takes place among animals such as the jackal hyæna and dog through buccal abrasions when feeding on trypanosome infected prey. Though as a rule obscure, the role of certain biting flies in transmitting trypanosoma to animals is fairly well known. For instance, Glossina morsitans, after feeding on an infected animal, and biting a clean animal, will infect it with T. dimorphon in 18 days, and with T. vivax in 15 days. Again we thus see how easily trypanosome infections of animals can be spread along trade routes by those animals in the service of man.

Nagana, one of the most important trypanosome infections of cattle and horses, is an African disease which with allied trypanosome infections, such as T. vivax, occur in districts where tsetse flies abound, and in others where they are entirely absent. The question of how to deal with T. Brucei, and allied trypanosome infections in Africa is thus rendered a matter of peculiar difficulty. As examples of tsetse infested, and Nagana infected areas in Africa, we may take Zululand, Bechuanaland, Matabeleland, Mashonaland, Mozambique, the banks of the Zambesi and Limpopo rivers, British and German East Africa, Somaliland, Congo Free State, Uganda Togo, and Sierra Leone. The species of tsetse, mainly held responsible for the spread of the disease are G. morsitans, G. pallipides, and G. palpalis. The wild animals known to be carriers of T. Brucei are the Buffalo, Wildebeeste, Hartebeeste, Koodoo, Hyæna, and Bush Buck. Dogs and jackals have been found infected after feeding on infected animals.

As examples of Nagana areas infected with Nagana and allied trypanosoma, where tsetses are unknown, and other biting flies are accredited with the role of vectors, we may take Algeria, where "Zusfana," a trypanosome infection of horses, and "Debab," another of camels occur; Erythrea, Abyssiania, Haut and Moyen Niger and the Camerons are also regions where cattle and equidæ suffer from similar tripanosomiases. In French Sudan, and Timbuctoo, we find "Mbori," in dromedaries and "Souma," in cattle and horses.

T. dimorphon is a fly-borne trypanosome, whose geographical distribution may be said to be within the wide equatorial belt of the African Continent, bounded on the west by Gambia, and Guinea, and on the East by the Anglo-Egyptian Soudan. It gives rise to trypanosomiases in horses, Bovdæ, and very probably mules, pigs, dogs, and sheep.

G. palpalis and G. morsitans are the varieties of tsetse incriminated in the spread of this disease. They draw their virus from wild game such as the wild antelopes along the Congo, whose blood was found to harbour the parasites. Here, again, much still remains unknown.

The question of the transmission of Caderas, T. equinum, a fatal disease of horses by biting flies, is one in which there is much obscurity. As yet no tsetse is accredited with this role. Fleas and mosquitoes have been considered carriers. In Algeria and India biting flies common in the neighbourhood of stables are incriminated.

Stomoxys calcitrans, and S. nebulosa, are said to spread the disease in the Phillipines, and Central South America. An interesting example of a particular species of animal, forming the natural reservoir for the infection of biting flies, etc., is seen in the case of the Carpincho hydrochærus carbera, a burrowing rodent in Argentine. Horses feeding in carpincho infested fields show epidemic "Caderas" when these rodents die in large numbers.

"Galziekte," the South African disease due to T. Theileri, and T transvaliense, is again a trypanosome infection of animals, the ætiology of which is incom-

plete. The biting flies supposed to transmit the disease are Hippobosca rufipes and H. maculatus.

"Surra," T. Evansi, one of the most wide-spread of all trypanosome infections in animals, is one where tsetse play practically no part in transmission. Several classes of biting flies are accredited carriers of the disease. T. Evansi occurs in cattle, horses, asses, camels, dogs, and possibly elephants. The wild jackal, hyæna, buffalo, have been found infected, and can thus act as reservoirs where the strain has died out in domestic stock. This trypanosome infection has further been noted amongst sewer rats in Manila.

Many biting flies have been proved vectors of this trypanosome. Schat states that Stomoxys calcitrans transmits the disease in Java. S. Niger and S geniculatus were said to have transmitted the fatal epidemic of surra in Mauritian cattle and equidæ from surra infected horses imported during the Boer war.

Musgrave and Clegg claim that positive experimental transmission between dogs and rats has been effected through infected fleas. Tabanus tropicus and T. lineola are said to be surra transmitters.

The importance of further work on fly carriers in this as well as other cattle trypanosomiases is shewn by the vast geographical distribution of surra, occurring as it does in India, Burma, Assam, Mauritius, Sudan, French, Indo-China, Hongkong, Perak, Persia, Yunnan, Cochin China, Cambodia, Java, The Dutch East Indies, Phillipines, Federated Malay States, and the Shan Provinces. It has also been reported from parts of Africa.

I do not propose to discuss the structure of the mouth parts of biting flies as these are more easily understood by specimens and illustrations of the more important types. From the above remarks, it will be seen how important it is that further study upon the life histories and morphology of ticks, biting flies and the parasites they transmit to vertebrates should be carried out. It is only upon such study by many workers, in many lands, that this generation can hope to attempt to check or eradicate the spread of diseases affecting the economic future of men and animals, diseases that cripple the further advance of civilisation and the opening up of our African colonies.

THE RÔLE OF NON-BITING FLIES AS CARRIERS OF DISEASE.

By J. T. C. NASH, M.D. (Edin.), D.P.H. (Camb.).

There are at present known roughly about 40,000 species of Diptera or true flies.

Some of these, but very few species indeed, have been proved to be transmitters of disease, and these are almost confined to the biting flies.

But when at the beginning of the present century the experiences of our troops in South Africa were being discussed in the journals, and we were also gaining new information as to the various species of glossina and as to their rôle in the spread of "nagana" and sleeping sickness, observers in England and elsewhere—all unconsciously, in all probability—began more than ever before to think of the ordinary Musca Domestica as a possible carrier of disease. Osler and Macrae instance an epidemic in Chicago in 1902 where 5 flies out of 18 examined were found to be carrying typhoid bacilli ("A System of Medicine," p. 87).

*In England I have persistently, year by year, since 1902 definitely urged the intimate association of domestic houseflies with the spread of English epidemic summer diarrhœa. The Annual Reports of the Medical Officer of Health for Manchester have also dealt with the subject since the year 1904.

In India, flies had already been suspected as "Carriers" for many years. For instance Davies in his manual of Hygiene (second edition), 1901, refers to the Gaya and Burdwan jail epidemics of cholera in India in 1894 and 1896 which were respectively attributed to flies by Haffkine and Macrae in the former instance, and by Buchanan in the latter. He also refers to Victor Vaughan's statement that the carriage of infection by flies in the national camp at Chickamauga in 1898 was proved beyond doubt, and quotes his own experiment with flies collected over ground trenched with excreta. The only growth he obtained from the flies was "Proteus Vulgaris" which organism was in his opinion derived from the imperfectly buried fæces.

But the most notable work which has come down to us from the nineteenth century is the classical and monumental monograph of Professor G. H. F. Nuttall, M.D., F.R.S., on "The rôle of Insects, Aracinids and Myriapods as "carriers in the spread of bacterial and parasitic diseases "of man and animals."

Appended to Nuttall's work is a bibliography giving over 350 references to the literature extant up to 1899, involving not only houseflies but also mosquitoes, fleas, lice, bugs, etc., etc., and their relation to plague, anthrax, cholera, malaria, filariasis, and other diseases.

With regard to plague much has been made of the part played by rat fleas, and indeed experiment has indicated that the disease is often so transmitted; but it is important to bear in mind also that (especially in a country like

* Discussion on Infantile Mortality in Essex, November, 1902, referred to in Vincent's book "The Nutrition of the Infant."

India where flies abound all the year round) flies may easily aid in the spread of infection. Nuttall gives a reference to the City of Bengasi in Tripolis which was visited severely by the plague in 1858-59 and lost two-thirds of its inhabitants by this disease. Bengasi had a population of 10,000, was very filthy, and was known as the " Kingdom of flies " among the Turks.

Yersin (†) from a single experiment in 1894 concluded that flies were capable of spreading plague, and Nuttall in 1897 (‡) made a series of experiments on flies (Musca Domestica) which conclusively proved that flies are able to carry the infection and that they die of the disease. Although the flies eventually died the majority lived some days, which fact points to the probability of flies playing no inconsiderable rôle in the spread of plague, for further experiment showed that the flies contained virulent bacilli 48 hours and more after they had been fed on infected organs, and had been kept in clean vessels. Flies have been proved to act as carriers of the tubercle bacillus among other germs.

With regard to diarrhœal diseases ordinary non-biting flies unquestionably play a very prominent epidemiological part. I am certain they will be proved to be among the chief causes of epidemic prevalence in India of cholera, typhoid fever, dysentery and other diarrhœal diseases.

In England I am quite convinced that during the warm summer and autumn months the domestic fly (Musca Domestica) is the principal pathogenic agent responsible for the frightful mortality among hand-fed infants by diarrhœa in an epidemic sense.

I (§) have carried out experiments which show how grossly even one or two flies can pollute milk in a bacterial sense in a few hours in warm weather. Many observers have recorded experiments which prove that flies can transport typhoid bacilli, cholera bacilli, and chromogenic organisms. In 1903 I pointed out (*a*) that the London diarrhœa curve closely corresponded with the numerical prevalence of flies. Jackson has recently shown that the same coincidence applies in New York.

At the same time I showed that the well known hypothesis of the late Dr. Ballard, a Medical Inspector of the Local Government Board, in reference to epidemic diarrhœa could be easily made applicable to the fly as the organism responsible for epidemic diarrhœa.

In England the diarrhœa curve is marked with a great wave of prevalence at one season of the year. I am not aware whether curves have been constructed or worked out for different parts of India, but it would be very instructive to work out such at different centres and compare them with the numerical prevalence of flies in the same districts and then compare the sets of curves among themselves.

One would not expect to find such a marked peak in the Indian diarrhœa curves as we experience in England, but still there would be quite appreciable waves of prevalence, and the point to determine is whether these do, or do not, as a rule, correspond with the excessive or diminished seasonal prevalence of flies. In the cold weather and in the cooler stations the curves would probably show nearer approaches to the English curve.

I am sure the systematised study of the rôle of house-flies as carriers of diarrhœal diseases in particular in India will result in much instructive and otherwise valuable information. Since it will be necessary for numerous observers to work throughout a year or two at stations widely separated throughout India, many investigators can find an interesting work to hand. Arrangements should be made for the reports of such investigations to come to a central compiler who will undertake to tabulate and compare the different reports and finally report himself on the result and conclusions to be drawn. Should this be undertaken I hope I shall be honoured with a copy of the report which would naturally be of intense interest to me.

As these investigations should precede action I will not at the present time say anything as to prevention, but I should be happy to contribute a word or two under this heading on a future occasion.

A preliminary essential is to trace the life history of the house-fly and other closely allied flies such as Homolomyia Canicularis, Pycnosoma marginale, etc. Valuable information on this point may be obtained from a paper by Austen (*b*) on the house-fly and allied species.

Later original work by R. Newstead (*c*) and C. Gordon Hewitt (*d*) have added much to our definite knowledge of the chief breeding places of flies in England. I am of opinion that similar careful work should be carried out in India on systematic lines. I am aware that the ground has already been broken into, (*e*) but there is ample space for further study and report.

Mr. C. Gordon Hewitt states that Prowezek has found a flagellated protozoon allied to the typanosome in the house-flies which he examined. The discovery of this parasite in the common house-fly is of great importance since it is believed that Kala-azar is due to a species of Herpotomonas. There is as yet no evidence that the H. Muscæ Domesticæ has been transmitted to human beings, but here again there is room for further research.

The capacity of the house-fly to carry disease germs has been experimentally proved by Nuttall (*f*), Firth and Horrocks (*g*) and other observers as I have already

(†) Annalles de l'Institut Pasteur, 1894, pp. 662-667.

(‡) " Zur Aufklarung der Rolle Welche Insekten bei Verbreitung der Pest Spielen. Ueber die Empfindlichkeit Verschiedener Thiere fur dieselbe" Centralbl f Bakteriol, XXII, 1897, pp. 87-89.

(§) " The Lancet," December 5th, 1908, p. 1668. " A Note on the Bacterial Contamination of Milk as illustrating the connection between Flies and Epidemic Diarrhœa."

(*a*) Trans. Epidemic Soc., Vol. XXII, 1902-03, pp. 44-47 and 127, 138. " The Seasonal Incidence of Typhoid Fever and of Diarrhœa," by J. T. C. Nash.

(*b*) E. E. Austen. Journal of the R.A.M.C., June, 1904.

(*c*) Preliminary report on the habits, life, cycle and breeding places of the common house-fly (Musca domestica), Liverpool, 1907.

(*d*) An. Rept. and Trans. of the Manchester Microscopical Soc., 1907. The Quarterly Journal of Microscopical Science, Vols. 51 and 52, pp. 395—448 and pp. 495—545 with plates, 1908.

(*e*) See valuable paper by Major F. Smith, D.S.O., R.A.M.C., on " House-flies and their ways at Benares," Journal of the R. A. M. C., Vol. IX, pp. 150—155, 1907.

(*f*) Op. Cit.

(*g*) " British Medical Journal," 1902.

shewn. With respect to typhoid fever reference is made in Osler and Macrae's System of Medicine to Fischer's estimation of the duration of life of typhoid bacilli as 23 days in the bodies of flies.

The experiments of my own (*h*) shew how grossly one or two flies immersed in milk for a few hours can pollute that form of food without reference to any particular germ. These experiments clearly prove that *putrefactive* bacteria *are* carried by flies under ordinary conditions of existence and are capable of giving rise to great chemical changes in milk which may easily prove of a toxic nature and induce severe diarrhœa.

In asylums and other large institutions the rôle of the house-fly as a carrier of diarrhœal diseases has probably hitherto been underestimated.

The indictment I have to bring against the so-called "harmless" house-fly is that he is probably accountable for more disease than his brethren who, armed with stabbing and cutting implements, conveys the blood diseases which have been clearly traced to Anopheles Maculipennis, Stegomyia fasciata, Glossina palpalis, and other biting Diptera.

(*h*) Op. Cit.

INDIAN SAND-FLIES.

By F. M. HOWLETT.

In this country there are three distinct kinds of flies which are called "Sand-flies." These are :—

(1) The very small *Chironomidæ* conveniently grouped under the old generic name *Ceratopogon*, which, speaking roughly, differ from the other (harmless) *Chironomidæ* in having comparatively short and stout legs, in carrying the wings when at rest folded scissor-like horizontally over the abdomen, and in having fourteen antennal joints in both sexes, the antennæ being plumose in the males. They are best known by their common English name of "Midges." Most of the larvæ live in damp places and some are aquatic. Speaking merely from personal experience I should say they are of comparatively little account in India, though their bite is very irritating, but I have heard that in the hills and in various jungly districts they are at times extremely troublesome, alike to men and cattle. There is a large number of hitherto undescribed Indian species.

(2) Flies belonging to the family *Simuliidæ*. Black-flies or Buffalo-gnats (the latter name indicates not only the habits but also the attitude of the flies, which is very suggestive of a bull charging on its victim). These are often erroneously called "Sand-flies" in the hilly country to which they are practically confined. The larvæ live attached to stones in rapid streams and torrents. There are several Indian species, but I believe only two have been described. All the members of the family suck blood and belong to one genus *Simulium*.

(3) The true Sand-flies, belonging to the genus *Phlebotomus* of the family *Psychodidæ*. The two large genera of Psychodids, *Pericoma* and *Psychoda*, both number many Indian species ; but of these at any rate the great majority never suck blood, though it is probable that one species at least occasionally does so. Until comparatively recently the presence of the genus *Phlebotomus* in India was hardly noticed, but it is now known that there are at least half a dozen Indian species,* all voracious blood-suckers.

Specimens of Indian Midges and Buffalo-gnats are exhibited. I shall here confine my remarks to a few points in the life-history and habits, as far as these are known to me at present, of the true Indian Sand-flies belonging to the genus *Phlebotomus*, as being the most important of the three types already mentioned.

If one makes an inspection of an average Indian bathroom, one usually notices on the window or walls some small hairy moth-like flies, with leaf-shaped hairy wings held so as to nearly cover the abdomen like a roof. These are Psychodids of the harmless genera *Psychoda* and *Pericoma*.

In addition to these one may also find sitting on the walls, more especially in rather shaded corners, other small flies resembling them in their general hairiness and inconspicuous greyish colour, but having much longer legs and a totally different resting-attitude. While the short-legged harmless Psychodids sit in what is roughly the same position that moths usually assume, these other Psychodid flies, which represent the blood-sucking genus *Phlebotomus*, stand with the body well raised on the long legs, the head down, the tail slightly depressed, and the wings well separated, their tips pointing outwards and upwards. If one of the flies be examined with a lens two points especially catch the eye ; first, the insect's look of devilish determination, and second the often remarkably long palpi, which in some species are carried bent twice at right angles or more, so as to bring the terminal joint to about the level of the base of the proboscis.

Except for slight differences in size and wing-venation the species are much alike, but they can be readily distinguished by microscopic examination of the structure of the male genital clasping-organs, which are particularly well-developed. It is extremely difficult to identify pinned specimens with certainty.

The investigation of the life-history of these flies is made somewhat difficult by the extremely small size of the young larvæ, which for many months rendered abortive all attempts to discover them in their natural habitat. Prior to my arrival in India Mr. Maxwell Lefroy had hatched larvæ from eggs laid in capitivity, but had not succeeded in getting them to live to the later stages, but at last, in August 1908, my assistant, Mr. P. G. Patel,

* Annandale and Brunetti ; "Indian Museum Records," 1908.

who has done a great deal of very good and painstaking observational work, succeeded in obtaining two larvæ, one from a small open drain channel. and the other from partially dried mud in a channel leading from a well-reservoir, and we were then able to ascertain the conditions necessary for successful rearing.

The eggs are ·10mm to ·15mm in length, oval-cylindrical, very slightly curved, and rounded at both ends. They vary in colour from yellowish to dark brown, being white when new-laid, and subsequently showing in some species a pattern of hexagonal reticulations, in others more or less parallel zigzag lines of darker colour. In number they vary from 30 to 80, the larger numbers being laid as a rule by the smaller species. Oviposition under natural conditions has not yet been observed, but in captivity the female moves about dropping here and there single eggs; the eggs when extruded are covered with a slightly sticky film and adhere to the surface on which they fall. When an area of one or two square inches has been thus dotted with single eggs, the rest of the eggs, perhaps half the total number, are deposited in one spot in an irregular mass. The females under observation have always died almost immediately after oviposition and sometimes even before the process was quite completed. Eggs can be hatched quite easily in ordinary glass tubes loosely plugged with cotton-wool, and, while they require the surface of the glass to be slightly damp, care must be taken to avoid excess of moisture and to exclude mould: they are unable to survive even a very brief exposure to the dry air of the hot weather. The time for hatching varies according to the temperature, from 4 to 6 days in the hot weather to 14 days at the end of November at Pusa.

The young larvæ emerge through a slit at the middle of one end of the egg. I shall not attempt to give here any detailed description of their structure, since their appearance is so characteristic that they can be easily recognised and distinguished from any other Dipterous larvæ. Their most easily observed and characteristic feature consists of two bristles or spines situated on raised tubercles at the caudal extremity, these bristles being remarkably long. often as long as the head and body together, and held conspicuously raised when the animal is walking: after about a week and at what is probably the second moult the number of bristles is increased to four. Besides these very long bristles the body and head are armed with stout sub-clavate spines, the blunt ends of these spines being broken up into a number of smaller sharp points, and six or eight being present on each segment. The head is large and distinct, strongly chitinized, with well-developed mouth-parts and a Y-shaped dark mark on the anterior dorsal surface. In general form and in the possession of body-spines they somewhat resemble the larvæ of some species of *Psychoda* and *Ceratopogon*, but can be easily distinguished from these by the absence of any foot-like process on the first thoracic segment and by the presence of the conspicuous caudal bristles.

The larvæ live in damp but not very wet earth, and their food consists of green algal growths. To rear them successfully it is necessary to supply them with this food, to guard on the one hand against drought, and on the other against excess of moisture and especially against any trace of mould, to give them fresh air at intervals, and to keep them shaded, since they are very susceptible to the effects of too strong an illumination, and die after comparatively short exposure to direct sunlight. When full grown the larvæ are from 2-3 mm. long.

The length of the larval life, as of the egg-stages, varies with the temperature and time of year. The shortest larval period observed has been 14 days in the rains, the longest 48 days. The change to the pupal condition is foreshadowed by a thickening of the thoracic segments, and by the larva seeking a comparatively dry spot. There the last larval skin is shed, the pupa emerging through a slit in the thoracic region, and by its wriggling movements working the skin down to the tail end, where it remains attached to the earth and holding the pupa in place.

The pupa, like the larva, has a very characteristic appearance, which can best be seen by looking at the specimens on exhibition. Its most distinct feature is perhaps the prominent ridges and projections on the dorsal surface of the thorax. The duration of the pupal stage, like the others, varies according to temperature from 8-9 days in the rains to 28 days in December.

The whole period of the life-history from the laying of the egg to the emergence of the fly from the pupa may thus be said to take about one month in the hot weather and two months or more in the cold weather. Observations have however not yet been carried on throughout the whole of the cold weather and the maximum length of life-history is not yet accurately known.

From the practical standpoint the chief interest of these sand-flies naturally centres in their blood-sucking habits. They are undoubtedly, in some districts and seasons, a far more serious pest than mosquitoes, owing partly to the fact that while a net is an adequate defence against mosquito-bites it affords no protection against the determined night attacks of *Phlebotomus*. The latter have not only the advantage of small size but inconspicuous appearance. They have been observed to make their escape from a glass tube in a surprisingly business-like way, by taking advantage of a narrow crevice between the cork and the glass very much smaller than the mesh of a mosquito-net: the long forelegs were pushed through the crevice until they got a hold on the edge of the tube, the insect meanwhile laying itself flat against the side of the glass, and the body was then drawn up after them. Against such determined methods a net is quite useless, and personally I have found the most effective, if rather unpleasant, remedy to be Hazeline or Lanoline with a slight admixture of kerosene, rubbed on the parts of the body most liable to attack. Oil of Lemon-grass, which is excellent for keeping off mosquitoes, seems to be of little use. My assistant tells me he has tried mustard oil with good results; I have not yet given it a personal trial. The flies not infrequently even crawl under the bed-clothes in their lust for blood, and the bite is to most people extremely irritating. The irritation continues

during the whole time that the fly is sucking, this time being about two and a half to three minutes when the operation is allowed to be completed without interruption. The effects vary in different individuals. On myself the bite results in a small reddish pimply swelling which persists for several days, the itching at first felt subsiding after a day or so. Children are especially attacked, and often seem to feel the irritation very much. Cattle, dogs, frogs, and caterpillars have also been observed to be sucked. The flies generally bite most freely in the early part of the night and just before dawn, but have apparently no very definite period, and I have been bitten in full light at 6-30 a.m. in September. There is no doubt that variations in humidity and temperature very greatly influence their biting propensities, and a sudden increase of humidity combined with a rise of temperature can generally be relied on to stimulate them to a special effort. In the act of biting the tail end is raised so that the line of thorax and abdomen makes an angle of forty-five degrees or so with the horizontal; the abdomen becomes very much distended with blood and except at the extreme tip assumes a transparent red colour: as digestion proceeds this red colour darkens and after about five hours the abdomen appears black; after sixteen hours half the abdomen has been emptied of its contents, while after thirty-six to forty hours the whole meal has been digested and got rid of. When first gorged with blood the insects fly with difficulty, and prefer to sit quietly digesting: they are then easily seen, and can sometimes be caught in the morning sitting inside the mosquito-net. At night they are attracted by light, but do not seem to care for very brilliant illumination. During the day-time they lie up in cool shady places in houses or elsewhere. They have been found under bricks lying in a pile, in hollow trees, behind shutters, pictures, boxes and almirahs, hanging clothes, and other places such as these. They are often found in bath-rooms, and still more often in latrines, where the males have been several times seen sucking the moisture from the dirty soil. It is probable that they are attracted to such spots by the smell of the nitrogenous matter, since they have been observed by my assistant to congregate in some numbers on an infant's sleeping rug which had been soiled with urine. That it is not the males, but only the females that suck blood may be, I think, taken as proved, for out of a large number of males seen none have ever been caught biting and none have been seen with any trace of blood in the stomach.

Copulation appears most usually to occur between 7 and 10 p.m. but has not been observed on many occasions. The flies place themselves tail to tail, facing in opposite directions, the abdomen of the female firmly grasped by the male claspers, and they remain coupled for about a quarter of an hour. The period which normally elapses between copulation and egg-laying is not accurately known, and may depend on circumstances. In those cases where copulation has been observed, the females most usually sucked blood (whenever they had the opportunity) very soon afterwards, and deposited their eggs some two days later.

In this connection a point of considerable importance arises Several observers have held the view that the females of various blood-sucking flies may require a meal of blood before oviposition can occur. It seems that this is very probably the case with Phlebotomus. It has just been said that females apparently desire blood very soon after copulation: several females in which copulation had not been actually observed have been caught after sucking, the abdomen before sucking having (as far as could be seen with the naked eye) no enlargement such as is visible when it contains well-developed eggs. After sucking, the abdomen becomes as previously mentioned much swollen with blood, and is emptied after about thirty-six hours. Now in most of these females the abdomen when emptied of blood still remained much distended, not with blood, but with eggs which were afterwards laid (this also is exactly what happened in the case of the females just mentioned which were observed to copulate and afterwards to suck): in others, the abdomen, emptied of blood, collapsed to its normal dimensions, and in none of these cases were any eggs ever laid. It may be presumed that these latter females had not been fertilised, but had sucked blood before copulation had occurred, while the former fertilised females had sucked subsequently to copulation. No eggs have ever been laid by any females except such as were caught with abdomen distended either with blood or with fully developed eggs and this seems to indicate that blood may be an essential factor in bringing the eggs to maturity since they have never been observed to mature in the body except in cases where the abdomen contained blood at the time of capture. It seems probable that the excessive nutrition contained in a full meal of blood results in a rapid development of the eggs, and the extrusion of the undigested matter may even be in part a mere mechanical consequence of the great enlargement of the ovarian contents. I regret that pressure of other duties has hitherto prevented my testing the truth of this supposition, since apart from its purely physiological interest the question of how many times sand-flies will bite is obviously of importance in any enquiry as to the probability of their transmitting disease.

Of the distribution and seasonal occurrence of the various species sufficient material has not yet been accumulated to form an accurate idea. It seems that at least two species occur practically throughout India, while the remainder may be more restricted in their range. As to seasonal occurrence little can yet be said; flies of all the four species usually seen at Pusa are found to be most abundant at the end of September and beginning of October, and this seems to be also the case over most of North-East India. There are probably five to seven broods a year.

The object of this paper has been to place before you a rough outline of the life-history of Indian Sand-flies, and to provide some basis for future more detailed work on these insects in the event of their being discovered to transmit disease. The frequent opportunities of biting which they enjoy owing to their small size and determined way of getting at their victim, the probability that they bite at least twice in cases where copulation has not

taken place before the first bite, and the fact that the period of their maximum abundance coincides in many districts with the most unhealthy season of the year, when obscure short-period fevers are often prevalent, especially in such localities as are particularly favoured by the flies, seems to me to provide evidence for a *prima facie* case sufficiently strong to warrant further investigation.

DISCUSSION.

Dr. Arthur Powell said Phlebotomus had appeared in Bombay each March and April since 1906. He could endorse Mr. Howlett's description of the animal's ferocious aspect. Most laymen on being shown the insect under the microscope for the first time roared with laughter at the ridiculously fierce expression. A Native friend on being shown the insect exclaimed " kaisa takarari bainchut !!! "

The insect usually bit the wrists, and ankles and the latter being usually covered by the bed clothes the victim's first idea was that the agressor must be a bug Many a servant has been scolded and fined for allowing the presumed bugs to get into the house while all the time the culprit was Phlebotomus. The sensation of the bite was, in the speaker's opinion, distinctive, being of a hot, scalding character.

SNAKE VENOMS AND ANTI-VENOMOUS SERA.

By Major GEORGE LAMB, M.D., I.M.S.,

Director, Pasteur Institute of India.

I propose in the present communication to give a brief account of the position of our knowledge of the venoms of the poisonous serpents of India, and of the sera which can be obtained by immunising animals with these venoms. I shall endeavour to confine my remarks, as far as is possible, within the limits of the practical aspect of the question, leaving out those questions which are only of academic interest.

In India there are six common terrestrial snakes which can be said to be of any real danger to man. These are : (1) the Cobra (Naia tripudians) ; (2) the King Cobra (Naia bungarus) ; (3) the Common Krait (Bungarus cœruleus) ; (4) the Banded Krait (Bungarus fasciatus) ; (5) the Daboia or Chain Viper (Vipera Russellii); and (6) the Phoorsa (Echis carinata).

The first four of these species are colubrine snakes, while the last two are classed by naturalists amongst the vipers. There is no question that the Cobra, the Common Krait and Russell's Viper are by far the most deadly and account for the great majority of the 20,000 odd deaths which occur annually from snake-bite in India.

As well as these poisonous terrestrial snakes there are many of the Hydrophinæ inhabiting the sea along the Indian Coast. The most common of these is Enhydrina valakadien.

The venom of serpents is a secretion of the racemose glands, the homologues of the parotid glands, which are situated behind the eye, one gland on each side. The poison passes forward through a duct which opens by a small papilla at the base of the fang or poison tooth. This latter is a functional tube which opens on the anterior surface of the fang near the tip. By a complicated and most interesting mechanism it is so arranged that no leakage occurs and that the venom is discharged at the moment the fangs penetrate the skin. The amount of poison which a snake can inject is a point, as we shall see, of some importance. If a snake is allowed to bite an ordinary watch glass covered over with American cloth or sheet rubber, the fangs penetrating the covering and the jaws closing on the side of the glass, the poison is ejected and collects in the glass. Collected in this way the amount of dried venom which a recently captured cobra may yield varies from 200 to 370 milligrammes; a large daboia yields somewhat less, namely, 150 to 250 milligrammes. The quantity of poison obtained from the smaller Indian serpents is very much less.

The different venoms vary greatly as regards their degree of toxicity. The following table shows the minimum lethal dose for the rabbit of the venoms of the six common Indian species and of the common sea snake. The amounts are expressed in milligrammes per kilogramme of weight.

Species of snake.	By subcutaneous injection.	By intravenous injection.
Naia tripudians	0·35 milligrammes.	......
Naia bungarus	0·35 ,,	......
Bungarus cœruleus ...	0·08 ,,	0·04 milligramme.
Bungarus fasciatus ...	2·5—3 ,,	0·7 ,,
Enhydrina valkadien ...	0·05 ,,	......
Daboia Russellii	1·2 ,,	0·1 milligramme.
Echis carinata	1·2 ,,	0·05 ,,

From this table it is seen that the most toxic poisons are evidently those of the common sea serpent and the common krait and the least toxic that of the banded krait.

Of the intimate chemical composition of venoms little is known. They contain albuminous bodies, which are modified proteids in solution, and until recently all attempts to separate the toxic principles from the proteids had been unsuccessful. Lately, however, Faust has split off from the poisonous proteids of cobra venom a non-nitrogenous, highly toxic substance which he calls ophiotoxin.

Venoms are by no means simple solutions of one poisonous substance, and the more they have been studied the more complex have they been shown to be. According to their physiological actions they have been found to contain one or more of the following :—

(1) A powerful fibrin-ferment.
(2) An anti-fibrin ferment.
(3) A proteolytic ferment.

(4) Various cytolysins capable of acting upon red blood cells, leucocytes, endothelial cells of vessels, nerve cells, and the cells of various other tissues.
(5) Agglutinin for red blood cells.
(6) An anti-bactericidal body of the nature of anti-complements.
(7) A neurotoxin or neurotoxins, which have affinities for all nerve cells and especially for the cells of the respirating centre: the special affinities of these constituents vary in the different venoms.
(8) A neurotoxin which acts on the nerve endings, especially on those in the diaphragm.
(9) A substance which acts directly on the heart muscle, stimulating it and increasing its tone.

No venom yet studied has been found to possess all these constituents, and the dissimilarity in the effects produced on men and animals is due to the proportions in which the different groups of toxic substances occur in the particular poison. Further, it is to be noted, that, although two venoms may have a similar physiological action, it is not to be concluded that the substances which produce this action are chemically identical. This has been clearly demonstrated by means of the sera of animals immunised with different venoms, and has been specially shown in the case of their hæmolysins. The great importance of this question of specificity of venoms in connection with the serum therapeutics of snake bite will be at once evident, and I shall have to return to it when discussing the treatment of cases of snake venom intoxication.

We have now to consider briefly the physiological actions of the venoms of the common Indian species, in the light of what has been said above. For the sake of brevity I shall divide the poisons into two groups, the colubrine venoms and the viperine venoms. In the description of each of these groups I shall indicate in what manner the individual members of the group differ from one another in physiological action.

1. *Colubrine venoms*: (Cobra, King Cobra, Krait and Banded Krait).

The principal constituents of all these poisons are neurotoxins. They act on the cells of the central nervous system, especially on the respiratory centre in the bulb. Mammals become progressively paralysed until death ensues from failure of respiration. If the circulation be well maintained, as in cobra venom intoxication, the animal may be kept alive by artificial respiration for hours during which period reflex action is entirely abolished. The nervous system of monkeys killed with these poisons have been carefully examined microscopically. If the animals live long enough, *e.g.*, more than two hours, there is produced an acute chromatolysis of the ganglion cells throughout practically the whole cerebrospinal nervous system. These changes are, as a rule, more marked in the cord, less so in the cerebral cortex and least apparent in the pons and medulla. The longer the animals live after receiving the venom the more extreme is the chromatolysis.

As well as this action on the central nervous system these venoms have neurotoxins, which act upon the nerve endings in voluntary muscle, the phrenic nerve endings being particularly susceptible to this constituent.

The poison of the banded krait contains a neurotoxin peculiar to itself. If a small quantity of this venom be injected, the animal may show no acute symptoms, but after a few days, during which no departure from health is noticed, may suffer from a chronic wasting illness characterised by loss of appetite, great depression, irregular temperature and excessive muscular weakness. The muscles become more and more atrophied and the increasing weakness passes into a condition of general paralysis and death. The cells of the central nervous system of these animals show a very marked degree of chromatolysis.

The colubrine venoms influence the circulation both through a direct action upon the muscle of the heart and indirectly through the nervous system. The poisons of the cobra and the common krait, when very dilute, exert a marked stimulating action upon the heart. As the strength of the solution is increased the effect becomes more marked until the heart is brought to a standstill in systole. They have also a marked stimulating effect on the muscular walls of the arterioles, so that in intoxication with these venoms the blood pressure is maintained at or above the normal height. On the blood plasma these venoms act somewhat differently. The venoms of the two cobras and of the common krait contain no fibrin ferment, but the first two have a marked anti-coagulating action, that is to say, they are able even in small amount completely to prevent coagulation both "in vivo" and "in vitro." On the other hand, the poison of bungarus fasciatus contains a comparatively weak fibrin ferment. When it is injected in large quantity rapidly into the blood stream, death results from intravascular clotting. We find a similar action with the Australian venoms in which, however, the fibrin ferment is very powerful. It is to be remembered that all the poisonous Australian snakes belong to the Colubridæ.

Finally, these four colubrine venoms contain hæmolysins, the venoms of the two cobras in this respect being more active than those of the kraits. Hæmolysis is not, however, a marked feature of human poisoning by any of these poisons.

From what has been said above it will be gathered that in cases of human poisoning with the venoms of the cobras and of the kraits the symptoms are chiefly nervous symptoms. Locally, there is considerable pain at the site of injection, soon followed by swelling, tenderness and redness. The patient feels intoxicated, sleepy and weak in the legs. Nausea and vomiting are often early symptoms. Paralysis increases till he is unable to stand, and the tongue and larynx become affected. The breathing becomes slower and ultimately stops, the heart often going on beating for some time. Convulsions may precede the ultimate dissolution.

Should the patient survive the paralytic symptoms, he returns quickly into a state of complete health, except perhaps in intoxication with the venom of Bungarus fasciatus, in which case the chronic nervous illness to which I have already referred may supervene.

2. *Viperine venoms.*—(Daboia Russellii and Echis carinata).

The two common vipers of India are the Russell's viper and the phoorsa. The Crotalinæ are also represented by several species, the bites of which, however, are but seldom if ever fatal to men. The following remarks are confined to the venoms of the two former species.

With viperine poisons the direct action on the nervous system is not nearly so well marked as with the venoms of the colubrine snakes No changes in the nerve cells have been observed in monkeys killed with the poison of Daboia Russellii, although one which had lived for 60 hours was examined. The principal action of these venoms on the nervous system is that upon the vasomotor mechanism resulting in a striking fall of blood pressure. This action has been attributed to paralysis of the central mechanism. The respiratory centres do not appear to be directly affected.

The poisons of Daboia and Echis have well marked actions on the blood plasma, on the blood cells and on the walls of the arterioles. Both contain a powerful fibrin ferment, more powerful, however, in the venom of Echis than in that of Daboia so that when injected into the blood stream in small amount or in large quantity subcutaneously into small animals, almost instantaneous thrombosis takes place. If the amount is not sufficient to cause rapid death from intravascular clotting, then a secondary phase quickly developes in which the blood becomes incoagulable and may remain so for several days. Further, these viperine poisons have a marked destructive action on the blood cells, both red and white. They also destroy the continuity of the vessel walls, probably owing to a cytolytic action on the endothelial cells. As a consequence of these various actions on the circulatory apparatus, sanguineous discharges from the punctures and from the various orifices of the body are prominent features of viperine poisoning.

From what has been said above the symptoms which are likely to be observed in a case of bite from one of these vipers can be imagined. Locally, there is much swelling and ecchymosis which often extend a considerable distance from the site of the punctures: there is often serious hæmorrhage from the wounds which may last for several days.

The general symptoms are marked collapse, a small thready pulse, cold sweats, nausea and vomiting, pupils dilated and insensitive to light and often complete loss of consciousness. The patient may recover temporarily from these general symptoms only to fall into a deeper state of collapse than before. If recovery takes place from this state of depression, the local condition extends while there may be hæmorrhages from the rectum and other orifices of the body. Extensive local suppuration and sloughing, malignant œdema or tetanus may supervene. Albuminuria or hæmorrhage from the kidneys is a constant symptom.

Death may be delayed for several days and recovery is not at all uncommon.

It is to be noted that there is throughout an absence of paralysis and of any symptoms which might point to any direct action of the poison on the central nervous system.

Having given you a brief account of the physiological action of the venoms of the common Indian snakes and indicated the symptoms which are to be observed in cases of bites from these serpents I have now to pass on to the discussion of the treatment of these cases.

When a person has been bitten by a poisonous snake our efforts to influence the result should take two directions: (1) to prevent the absorption of the poison and (2) to counteract or lessen its effects on the organism.

(1) With the first object a ligature should immediately be placed on the limb above the situation of the bite. It must be lightly applied and of course where there is only one bone and not on the forearm or lower leg.

Next an attempt should be made to destroy as much as possible of the poison that remains in the neighbourhood of the punctures. This is best effected by careful, deep and free dissection, right down to the bone if possible. The wound should be washed with a strong solution of permanganate of potassium. Wall considers that the application of any destructive agent to an incision through the wounds is almost useless: he found experimentally that such a method sometimes succeeded after the injection of the poison with a syringe, but was without avail after the natural bite of a snake. The same difficulty will be met with in the method lately advocated by Sir Launder Brunton, Sir Joseph Fayrer and Major Rogers, in which method it is advised that incisions be made over the punctures with a lancet and crystals of permanganate of potash then be rubbed in. Although this method is successful in experiments, in which the direction of the needle through which the poison is injected is accurately known, in practice it can only be by chance that the permanganate reaches the poison, which may be placed deeply in the areolar tissue and at some distance from the punctures.

To suck the wounds is absolutely useless.

(2) As regards the efforts which should be made to counteract the effect of the poison on the organism, the only hopeful method of treatment is to inject some substance which will neutralise any venom with which it may come in contact. This leads me to speak of the important question of anti-venomous sera.

Calmette of Lille was the first to establish that an animal which had been treated over a length of time with snake venom yields a serum which is antitoxic to that poison. He then proceeded to produce an anti-venomous serum in sufficient quantity for therapeutic purposes. He claimed that this serum, prepared at Lille with a mixture of snake venoms, in which mixture, however, cobra poison greatly preponderated, was antitoxic to all kinds of venoms, and therefore could be advantageously used in cases of bites of all species of snakes.

I have not the time to enter into the details of the long controversy which followed on this statement of Calmette. Suffice it for our present purpose to say, that it has now been definitely shown that Calmette was wrong and that all observers, with the exception of Calmette himself who has not yet acknowledged his mistake, are agreed that anti-venomous sera are highly but not strictly specific. The bearing of this conclusion on the problem of the serum therapeutics of snake bite is evident, for we are met with the almost insurmountable difficulty, that only the specific anti-serum will be of use in a case of snake venom intoxication. The serum, which is now issued from the Central Research Institute, Kasauli, for use in India, is prepared with a mixture of Cobra and Daboia venom. It is, therefore, useful only in cases of bites from one or other of these species and no good can be hoped from its use in cases of bites of the Kraits or of the Phoorsa.

Again, Calmette considers that 10 to 30 c.c. of serum is sufficient in all cases of bites, even of the most deadly snakes, and further recommends that the injection should be made subcutaneously.

Now, in order to arrive at an accurate therapeutic dose of an antivenomous serum three factors must be determined: (*a*) the neutralising power of the serum, that is to say, the exact amount of serum which can neutralise a given amount of venom; (*b*) the amount of poison which a snake can inject; and (*c*) the quantity of venom, the injection of which a man can survive.

Let us consider these factors in the case of a cobra bite:—

(*a*) The strength of the serum now issued from Kasauli is such that 1 c. c. can neutralise 1 milligramme of dried venom, when the mixture is made "in vitro" and then injected. So far it has been found impossible to prepare a stronger serum than this.

(*b*) I have already stated that a fresh adult cobra may inject as much poison as the equivalent of from 200 to 350 milligrammes of dried material. Although in many cases it is probable that a good deal less venom would be injected, it should be borne in mind that the snake may have thrown in as much as 350 milligrammes, for the neutralisation of which quantity sufficient serum would have to be given in order to save the patient's life.

(*c*) As regards the third factor, for an average man the lethal dose of cobra venom has been estimated at from 15 to 20 milligrammes, a quantity which is almost negligible, in view of the large amount which a cobra may inject.

From the above data we can calculate that, if a cobra has injected the maximum amount of venom possible, in order to neutralise this quantity and thus save the life of the patient 300-350 c.c. of serum would have to be brought in contact with it.

Further, it has been shown that if the serum be injected subcutaneously the amount required to neutralise a given quantity of venom, which has also been injected subcutaneously, would be 10 to 20 times that required if the serum was given intravenously or if the mixture was made "in vitro" before injection. If, therefore, Calmette's recommendation be followed and the subcutaneous method of injection used, we must multiply our dose at least 10 times. There are, of course, many cases of snake bite in which for many reasons the snake does not inject anything approaching 300 milligrammes of poison and for such cases treatment with a much smaller quantity of serum would suffice. It is, in fact, probable that the great majority of cases would come into this latter category; but it must always be remembered that if the larger amounts of serum are not used and if the injection is not made intravenously, the treatment may fail because more than a lethal dose of poison remains unneutralised.

For the reasons which have been set forth above the following instructions should be followed:—

(1) The serum should be injected as soon after the bite as possible.

(2) The injection should always be made intravenously.

(3) At least 100 c. c. of serum should be given.

As regards the treatment of snake bite, other than by antivenomous serum, little or nothing can be done beyond keeping the patient quiet and warm. Small doses of alcohol may be beneficial, but the employment of enormous doses cannot receive too strong a condemnation. Ammonia or strychnine will serve the same purpose as alcohol.

In cases of viperine intoxication, adrenalin chloride should be given to counteract the paralytic action on the vaso-motor apparatus.

SOME REMARKS ON
SNAKE-BITE AND THE TREATMENT OF SNAKE-POISONING.

By Major F. WALL, I.M.S.

When first asked by the Secretary of this Congress to read a paper on snake venoms I declined because I felt there was little if anything original that I could say on this subject, but as an interested student of the work of others in this field, I have reconsidered the matter and am prompted to make a few remarks upon certain points which I think required greater emphasis than has been conceded to them.

In the first place in reading the reports of snake casualties which appear from time to time in various publications, I have been forcibly and repeatedly struck with the very incomplete way in which many of these cases are recorded, and also by the fact that in many cases the diagnosis of snake-poisoning or ophitoxæmia appears to have been quite unjustified. Frequently one or two of the most obvious symptoms in a case are mentioned—not necessarily symptoms of ophitoxæmia at all—to the exclusion of many others which though less obvious are perhaps of greater importance in establishing a diagnosis. It appears to me that the term "snake-bite" is often used as synonymous with "snake-poisoning," and the mere fact that a man has been bitten by a snake, or is reported as having been bitten by a snake has been the only justification for considering and recording the case as one of snake-poisoning. Many cases appear to be recorded as snake-poisoning which should have been returned wound punctured, or wound lacerated.

Now in many cases of snake-bite whether the wounds are inflicted by a harmless or a poisonous species a certain train of symptoms follow which are the direct result of fright and fright alone. Some of these are so serious that they end fatally, but whether fatal or not a great many of these cases are wrongly diagnosed, the symptoms due to fright being misinterpreted as the result of snake-poison.

The gravity of symptoms due to fright does not appear to me to be sufficiently recognised, though there is no doubt in my mind that fatal cases from this cause are abundant, especially among the timid natives of this country.

To take examples Fayrer* records the case of a man who was bitten by a slow loris (*Nycticebus tardigradus*) a perfectly harmless little creature of the order Primates. Natives believe that the bite of this animal is fatal, and this man sharing the conviction of his race, became alarmed, and within 5 minutes was in a senseless state necessitating 5 or 6 hours of vigorous stimulating measures to restore him. Mr. M. H. Oakes has written to me of a fatality from the bite of a "bis cobra", one of the monitor lizards probably *Varanus bengalensis*. The subject was a woman of 50 who was bitten on the toe, and she died in 1½ hours. I believe there is not the slightest doubt that this lizard is completely innocuous. Mr. E. E. Green† remarks that year by year in Ceylon the Registrar General's annual mortality report returns one or more cases of death from the bite of the brahminy lizard (*Mabina carinata*) a little skunk which is perfectly harmless, though the natives think otherwise. Dr. Willey † reports the death of a woman from the bite of the common wolf snake (*Lycodon aulicus*) a perfectly harmless species, and Dr. Ewart met with serious symptoms after the bite of the same snake, all of which were due to fright. I have known a man lie prostrated and unconscious for 17 hours after a bite from the harmless water snake (*Tropidonotus piscator*).

Now it appears to me that quite a large number of cases are reported each year as snake poisoning which have never shown a symptom of toxæmia, but which are comparable to the cases quoted above, the gravity of the symptoms being wrongly interpreted as due to the action of snake venom.

I think the conditions to be met with in the two states, *i.e.*, fright and snake poisoning require emphasizing, especially as they are in almost every detail strikingly different, and as a result call for completely different methods of treatment.

To begin with fright operating through the nervous system mainly affects the heart. The symptoms may vary from a transient pallor and giddiness, to a syncope of so profound a nature that unless combative measures are speedily employed the condition may pass insensibly on to death.

Now if we take the cobra as the type of a colubrine snake the toxæmia produced by its bite exerts its main force upon the nervous system, and principally operates upon the respiratory centre, the heart remaining unaffected. The constitutional effects seen in the two cases are as follows:—

FRIGHT.	COBRA-POISONING.
(1) Onset of weakness often sudden.	(1) Onset of weakness very gradual.
(2) Involuntary prostration; often the patient falls in a faint and is brought in this state to hospital.	(2) Recumbency voluntary after sometime owing to gradual loss of power of legs. The patient often walks to hospital by himself or with help.
(3) Complete or semi-unconsciousness.	(3) Consciousness not impaired.
(4) Syncope.	(4) Heart not affected.
(a) Pallid face,	(a) Face natural at first, livid later on,
(b) Cold clammy skin,	(b) Skin warm,
(c) Feeble or imperceptible pulse.	(c) Pulse of normal force and regularity.
(5) Breathing shallow, sighing and weak.	(5) Breathing gradually becomes more and more laboured, and quickened; gasping towards close.
(6) No paralyses.	(6) Paralyses. Gradual weakness of legs mounting upwards to trunk and head. The head droops. The eyelids droop. Symptoms exactly like bulbar palsy appear. Swallowing becomes difficult, the lower lip falls away from the teeth, and saliva dribbles from the mouth. Articulation too becomes difficult.

The symptoms of fright often very speedily declare themselves, far more speedily than is ever the case in snake poisoning. In some reported cases we read that the patient is seen or is brought to hospital in a senseless or

* Thanatophidia, p. 61. † Spolia Zeylanica, April 1908, p. 104.

nearly senseless condition it may be a few minutes after the bite, and as one reads the record it seems that this unconscious state has been interpreted as the outcome of absorption of venom, and remedial measures have been at once taken on this supposition. Now I think it is impossible in most cases of ophitoxæmia to diagnose the state from the general condition of the patient for an hour, or even more, for the reason that up to this time no general symptoms referable to the poison have manifested themselves. In addition syncope due to fright will often mark the general symptoms evoked by snake poisoning. Early paralytic symptoms would naturally be effaced during partial or complete unconsciousness due to syncope and there may be nothing to call attention to the ophitoxic state under such circumstances for sometime until in fact the respiration is affected. Under these circumstances it appears to me, that in most cases of reputed snake bite, if not all, the general state of the patient should be entirely disregarded in making a diagnosis, and attention should be wholly directed to the state of the wounds inflicted. Even when the snake is produced, and proves to be a Cobra or similar deadly snake it does not necessarily follow that venom has gained entrance to the wounds. From these one may learn at a glance whether venom has been injected or not, in most cases, probably all, the local symtoms of an envenomed wound being characteristic. The points to pay attention to are :—

(1) *Pain.*—Where venom has been injected pain is an almost certain symptom. It is burning or stinging in character, often extremely acute and it comes on immediately. It is possible that the stings of certain other creatures such as scorpions, spiders, hornets, etc., might be as severe, and as rapidly produced ; but if pain is experienced only to the degree normally met with in ordinary wounds from mechanical agency, it is highly probable if not actually certain that poison has not been introduced.

(2) *Swelling.*—Snake venom is an extremely powerful local irritant, and as such causes swelling in the injured part almost at once similar to that seen after the bite of a mosquito. Swelling to an equal degree, and as rapidly manifested might result from insect or scorpion stings. If however no trace of swelling accompanies the wound, there is good reason to consider no poison has gained entry, and the longer the interval since the bite the greater the justification for assuming a non-venomised wound.

(3) *Bleeding.*—One of the chief effects of snake venom, whether colubrine or viperine in quality, is its power of reducing the coagulability of the blood, and this fact affords very valuable information as to whether or not venom has been introduced into a wound, since when it has gained entry a constant oozing of thin bloody serum results which often continues for many hours. In a case recorded by Lamb and Hanna this continued for 24 hours. If lacerations or punctures are seen sealed up with blood within a few minutes of the casualty as in the case of ordinary wounds there is very strong justification for believing that no poison has been injected.

(4) *Tissue changes.*—Should the presence of any of the above local conditions call for local operative measures, the condition of the tissues as revealed by incision will furnish confirmatory testimony of the entrance of snake poison which, in the opinion of my namesake A. J. Wall, is absolutely characteristic. He says the areolar tissue becomes purple in colour and infiltrated with coagulated purple blood-like fluid. This fades gradually to a pinkish colour, and this again to normal conditions as the site of the poisoned wounds are receded from. These changes are extremely rapidly produced having been seen by this authority within 30 seconds of the entrance of the poison.

To the surgeon this sign is invaluable. Its presence proclaims the envenomed nature of the wound, and dictates a course of action completely different from that necessary in its absence.

I have now seen twelve cases of reputed snake-bite in this country, one of which was without doubt one of snake-poisoning, the viper being produced. I have always been guided by external signs, have in consequence never administered antivenene, and every case has recovered.

Before quitting the subject of local signs I wish to make a few remarks on the characters of wounds resulting from snake-bite due to mechanical causes alone. There is a popular belief that the pattern left by a snake's teeth in the act of biting can furnish a clue to the poisonous or non-poisonous character of the offender. Fayrer has done much to foster this belief by his illustrations of the dentition marks of certain snakes, and in his remarks on this subject in I.A.F.M. 1248 given to Military Hospitals with directions for the treatment, etc., for snake-bite these views are reiterated. Without denying that it may sometimes be possible to guess at the nature of the snake I am very decidedly of opinion that in the generality of cases of snake-bite it is quite impossible for even an expert to say from the character of the wounds whether the snake that occasioned them was a harmless or poisonous variety. I might even go further, and say it is impossible to say with any proximation to certainty whether the wounds were inflicted by a snake at all. Vincent Richards says *apropos* this subject "Not the slightest reliance is to be placed in the appearance of the scratches, or punctures though very much stress has been laid upon them as a means of diagnosing the bite of a venomous snake." A. J. Wall similarly remarks : "Now the mark of the teeth is no guide, or next to none, because a cobra may not leave a single mark

visible to the naked eye ; and on the other hand fanged harmless snakes, like *Lycodon* and *Dipsas* may leave punctures in the skin that might easily be mistaken for the wounds caused by the fangs of venomous snakes." I have several times been bitten by harmless snakes including those referred to by A.J. Wall that have long fang-like teeth situated like those of poisonous snakes, and in all cases the wounds have been lacerated, not punctured. Generally speaking a snake cannot make its jaws meet tooth to tooth on the flesh, its mouth being too small to grasp the limb or other part but it fastens itself obliquely, and the teeth slip off and tear the skin. The points to emphasize then in being confronted with a case of reputed snake-bite—

(1) Be guided by the local conditions rather than the general in distinguishing ophitoxæmia from non-toxic snake-bite.

(2) Be prepared to find symptoms directly due to fright in every case of snake-bite, look for them, and discount them in forming a diagnosis, but never ignore them. Treat the syncope thus arising, otherwise in a genuine case of ophitoxæmia after a liberal and sufficient dose of antivenene in a suitable case, death may occur and be wrongfully ascribed to the toxæmia. Under such circumstances the efficacy of antivenene may be questioned as indeed it has been by Lamb. Lamb * in 1904 collected three cases of cobra toxæmia which proved fatal in spite of treatment with antivenene. He argued that the dose of the serum was insufficient, but though that may have been so, it seems possible if not highly probable that death may have arisen from syncope complicating the toxæmia.

In cases complicated with syncope active stimulating measures are demanded, and such drugs as Alcohol, Ammonia and Strychnia are of the greatest value. These drugs have proved beyond question most useful in cases of snake-bite, so much so indeed that until very recent times they were credited with the false reputation of being antidotal to snake poisons. The reason is very apparent ; they successfully combated the state of syncope so frequently seen in these cases ; but, though we now know that they are utterly useless, or probably harmful in the state of ophitoxæmia, I do not think the use of Ammonia and Strychnia is contra-indicated in genuine cases of ophitoxæmia which are complicated with syncope, but that their exhibition is demanded to an extent sufficient to restore vigour to the heart. Alcohol appears to be contra-indicated wherever antivenene is employed for in a summnary of a paper by Calmette and Massol reported in the *British Medical Journal* for October 3rd , 1908, I notice these observers state that cobra antivenene is destroyed by this drug.

The incomplete and unsatisfactory fashion in which many cases of snake-bite are reported makes one feel that much valuable information relating to the clinical

* *The Lancet*, November 5.

manifestations of the various ophitoxins is being lost to science each year, and with regard to many of these ophitoxins we know absolutely nothing. I would propose that every case of snake-bite should be returned on a prescribed form similar to those now in use for recording cases of cancer and enteric fever. If all cases were so returned a greater uniformity and value in the records would be forthcoming, one would be able to judge the constancy of the signs both local and general which accompany the various forms of poisoning, any differences in the clinical manifestations occasioned by the various venoms would become apparent, one would be able to discriminate between genuine and spurious cases of ophitoxæmia, and possibly form some opinion as to the number of fatalities in India, reported as snake-poisoning, which are due to poisonous bites as compared with non-poisonous. I would propose a form somewhat as follows :—

Casualty return of snake-bite.

Station.
Sex.
Age.
Date and hour of bite.
Hour of admission.
Part bitten.
Species of snake.
Result____________ If fatal, method of death, Syncope or Asphyxia ________ Time elapsed since bite________

Symptoms, *Local*—
(*a*) Pain*
(*b*) Swelling†
(*c*) Sanious oozing
(*d*) Appearance of tissues when cut into________
____
(*e*) Characters due to mechanical causes________
____

General—
(*a*) Consciousness.
(*b*) Respiration.
____
(*c*) Syncope, Pallor.
Warmth and activity of skin ________
____
Pulse________
Vomiting________
Onset of weakness.
(*d*) Paralyses.‡ Onset of weakness________
Sequence________
Drooping head________
Drooping eyelids________

* If ligature applied previously discriminate between the aching pain so caused which is relieved by relaxing the band, and the burning pain of venom which occurs *immediately* after the bite.

† If ligature applied previously discriminate between that due to this cause which is equally diffused, and reduces when bandage relaxed and that due to venom which is greatest at site of wound, immediately produced, and which diminishes as seat of wound is receded from.

‡ Distinguish between the weakness often suddenly produced which is due to syncope and that appearing after some interval with gradually and increasing severity.

Articulation_______________________________
Phonation_______________________________
Deglutition_______________________________
Salivation_______________________________
(*e*) Hæmorrhages___________________________
(*f*) Other symptoms_________________________

Treatment.

In addition to this I would suggest that in every case where a snake is produced it should be sent to the Parel laboratory, the Bombay Natural History Society or the Indian Museum. for competent and confirmatory identification, no matter whether believed to be harmless or poisonous. I would further suggest that steps be taken to preserve a specimen of every poisonous snake likely to be met with in any station. The station hospital would be a convenient place to store these specimens, for handy reference when a case of snake bite occurred. The possible number of species in the plains is usually very small, and a representative collection of the poisonous varieties could be easily acquired. To take the United Provinces only 3 would be necessary, the Cobra, the Krait, and Wall's Krait. In the Punjab only 4, the Cobra, Russel's Viper the Echis and the Krait. In Burma 7, the Cobra, the banded Krait, the many banded Krait, the Burmese Krait, the Hamadryad, Russell's Viper, and the green pit Viper.

To pass to another consideration I would remind you that there are now known to be at least 39 species of poisonous terrestrial snakes inhabiting our Indian Dominions, besides some 50 species of sea snakes.

In the treatment of snake poisoning we have in the Kasauli polyvalent antivenene what we believe to be a specific in the bites of two species only *viz.*. the Cobra and Russell's Viper. and we know that for practical purposes this antivenene is useless against the poisons of any other snakes.

In Clifford Allbutt's last Edition of Medicine the article on snake poisons may be assumed to be the standard one, written as it is by two such distinguished workers in ophitoxicology as Martin and Lamb. It is disappointing to see that these two authorities confine their remarks on the treatment of snake-bite other than by antivenene to a few lines, and that they state that beyond antivenene nothing can be done in cases of snake poisoning but keep the patient quiet and warm, applying a ligature, and excising the wounded parts and apply strong permanganate of potash solution. I would criticise these remarks in two ways. firstly I cannot agree that either ligature or excision have proved their worth in practice, or are likely to judging from experiments in which they have been tried, secondly I think there are other means than those mentioned at our disposal from which one may expect good results.

I think I am fairly if not completely accurate when I say that in every text book treating of the subject of snake poisoning, ligature is recommended as one of the most essential practices to be adopted. This being so it appears to me that the lessons to be learnt from the magnificent experimental work carried out by the late Sir Joseph Fayrer have gone completely unnoticed. I will quote some of the experiments conducted by that great authority. and then ask you if ligature as usually practised is entitled to rank as the valuable measure which has unanimously been conceded to it.

In experiment 4 of the 15th series a ligature well soaped to make the knot run easy was tied "with the greatest amount of tension that a man's hand could exert" round a fowl's thigh *before* a bite was inflicted by a cobra below the ligature. This however did not prevent the absorption of the poison. Symptoms appeared in 23 minutes and the fowl died in 43 minutes from the typical effects of cobra poison.

In experiment 2 of series 15 a dog's forearm was bitten by a cobra. Within 5 seconds a soaped ligature was "tightened as firmly as a man's strength could draw it" and immediately strong carbolic acid was rubbed into the wound and then a red hot iron applied. The dog died in 11 minutes (not 21 as stated by Fayrer).

In experiment 14 of series 16 a dog's forearm was bitten by a cobra. A ligature "was tied as tightly as it could be drawn" within 2 seconds of the bite. Carbolic acid was applied locally and 10 drops of carbolic acid in an ounce of water given internally. Death took place in 51 minutes.

In experiment 13 of series 16 a dog's forearm was bitten by a cobra. A ligature was immediately applied "as tightly as two persons could pull it," and the parts disorganised with the actual cautery. Yet the dog died in 35 minutes.

It must be noted here that in five other experiments on dogs in which no treatment was carried out at all, the average duration of life after the bite of a cobra was less than 36 minutes, so that the ligature in three cases quoted above could not even be claimed to have postponed the fatal issue which took place in 11, 51, and 35 minutes respectively or an average of 32 minutes.

Now it must be borne in mind that in these experiments the assistants were ready and everything was to hand in anticipation of the coming events. The utmost expedition therefore was enforced, and yet the procedure proved a signal failure. It is manifestly impossible for any surgeon to apply a ligature in practice with anything approaching the despatch which characterised Fayrer's efforts. Further if the circulation cannot be controlled by a ligature on a dog's leg where the muscular tissues are comparatively moderate, and we are told in one case that the united strength of two men was insufficient to accomplish this, how vastly more difficult will its arrest be in the much larger muscular development of the human arm or leg.

Fayrer* himself says "it is almost physically impossible with the power of one pair of hands to so tighten a cord round a dog's leg as thoroughly to strangulate the limb." Wall (A.J.) † too says: "an ordinary cord or string, or bandage, is nearly useless compared with the India rubber

* Loc. cit., p. 103. Ind. Snake poisons, p. 139.
† Indian and Australian Snake Poisoning, p. XXI.

band. I have known fatal absorption take place when a string has been applied so tightly as actually to cut the flesh, and apparently strangulate the limb completely, causing acute suffering, evidently from the cord not accommodating itself accurately to the form of the member, and thus leaving a small channel for the circulation". Wall thus indicates the faultiness which, if there is any virtue in ligature at all, lay in Fayrer's technique. My remarks upon ligature above are only intended to apply to the application of a cord or in elastic band which, as far as my limited experience goes, is the method usually adopted in attempting to arrest the circulation in cases of snake poisoning. In all the cases I have seen treated, or questioned bitten subjects upon this form of ligature had been used. Mine may be a unique experience, still it is a fact, and as long as our text books continue to advocate ligature without specifying what is intended by this term, and refrain to warn the operator of what is known to have proved useless in this procedure so long will futile ligature be practised.

Now Wall (A.J.) tested the use of Esmarch's bandage with very marked results, and says: "the India-rubber band is nearly painless, and properly applied is an absolute safeguard against further absorption." As far as I can ascertain the elastic band was but twice applied by Wall, once in the human subject, and once experimentally in a dog, and in both cases recovery was complete. I do not think these two cases sufficient test of the method, and I am inclined to think therefore that Wall was too sanguine in his opinion.

My reasons for doubting the value of ligature, as applied even on the lines advocated by Wall, are based upon experiments by Fayrer with regard to excision and amputation.

In experiment 14 of series 15 a fowl was bitten in the thigh by a cobra. The part was immediately excised but the bird died in 21 minutes.

In experiment 11 of series 16 a fowl was bitten in the thigh by a cobra. The part was "immediately" excised (within 2 seconds). A ligature applied before the bite was relaxed just before excision. Death took place in 64 minutes.

In experiment 3 of series 16 a dog was bitten by a cobra in a fold of skin in the groin. The wound was entirely excised "at once," but death took place in 60 minutes.

In experiment 13 of series 15 a dog was bitten by a cobra in a fold of skin in the groin. The part was "immediately" excised (within 2 seconds). The animal succumbed in 2 hours and 35 minutes.

It is to be observed that in 7 experiments in the cobra-bitten fowls, all bitten in the thigh, the average duration of life was rather less than two minutes (116 seconds), so that it is clear that excision performed under very exceptional circumstances, so exceptional indeed that they could never be repeated in general practice merely prolonged life, did not save it. With reference to the two experiments on dogs too it must be remarked that the skin of the groin was held up with forceps, so that the injury sustained could only have implicated the skin, and too that such a proceeding offered every facility for complete removal of the poisoned tissues, yet in spite of this death was not averted.

In experiment 6 of series 16 a cat was bitten in the tail by a cobra. Amputation was performed in 20 seconds, but sufficient poison had been absorbed in this brief interval to give rise to profound toxæmia, the breathing became hurried, and the dejecta sanguineous. Under the circumstances though the subject did not die, one may well question the chances of success of amputation in practice. When one reflects that over and above the delay already occasioned in summoning medical aid, there is the time taken in selecting and preparing one's instruments, and getting the patient under an anæsthetic.

Now if complete removal of the poisoned area by excision and amputation within a few seconds of the venom entering the tissues failed to prevent a lethal dose being absorbed, as shown by Fayrer's experiments, what possible hope can there be for ligature performed under any circumstances.

Permanganate of Potash.—It has for many years been well known that this salt destroys the properties of snake venom when mixed with it in a vessel and it is a notable fact that though snake venoms vary considerably in their composition this action of permanganate appears to be equally effective with all. It will neutralise nearly its own weight of venom. The discovery lay with Winter Blyth, I believe, and the observation has been confirmed by Fayrer and many others. Brunton and Fayrer, experimenting with strong solution on animals poisoned by cobra venom found it disappointing as a therapeutic agent; however, de Lacerda in 1881 experimenting with a 1 per cent. solution upon dogs poisoned by the venom of an American pit viper (*Bothrops jararacussu* Vel. *Lachesis lanceolatus*) was led to consider it a very valuable remedy, and claimed for it that the neutralisation of the poison would take place in the tissues if the salt was injected locally. He found that injections made in from 5 to 10 minutes after the inoculation of venom prevented any further danger, and that even if made some hours after the injury when the toxic effects were apparent it still gave good results. The poison of the *Bothrops* being much less virulent than that of the cobra probably explains these conflicting results. Richards* in 1882 performed nearly a hundred experiments to test its therapeutic efficacy against cobra venom, and came to the following conclusions.—I. Lethal doses of cobra venom mixed with from 1 to 3 decigrammes of permanganate, and then injected produced no symptoms. II. If the two substances were injected into the same locality independently of one another, the permanganate even 4 minutes after a lethal dose of poisons no symptoms ensued. III. After the development of toxic symptoms the injection of permanganate was useless. IV. Permanganate injected some hours before the venom was useless. V. That to be efficacious the permanganate

* Ibid. p. 153.

must come into actual contact with the poison. He says later. "It is in my experience, the best local application we possess. It is not a physiological antidote, but a chemical one." Fayrer supports this opinion but realises the difficulty that may occur in bringing the two substances into intimate contact in the tissues.

Now it appears to me there is no difficulty in bringing the two substances into intimate relationship in the system if the permanganate is injected into the blood stream instead of into the tissues. As far as I am aware this has never been done, and I think that exhaustive experiments should be made on the lower animals with a view to determining the efficacy of this agent, administered in this fashion, and fixing a dose.

The outlook seems a promising one from analogy. Antivenene when mixed with the venom, for which it is specific, in vitro is known to neutralise it. When injected into the tissues is known to act beneficially if it is not actually curative by this procedure. Lamb however showed that where toxic symptoms were manifest reliance was not to be placed on hypodermic administration, but that intravenous injection offered the best hopes of a favourable result.

Should the intravenous injection of permanganate prove beneficial or curative, the fact that de Lacerda found it neutralised the poison of a viper, and Vincent Richards that it destroyed the virulence of the venom of a colubrine snake, *viz.*, the cobra, makes it appear certain that its curative powers would be active for all snake venoms.

The same arguments that apply to permanganate, one may presume, apply equally well to other agents of the same nature such as the hypochloride of lime, and the chloride of gold which are known to neutralise snake venom in vitro.

To pass to another consideration it seems to me remarkable that in the treatment of cases of snake poisoning which are reported as having ended fatally, one rarely, if ever, finds recourse having been had to artificial respiration, though the marvellous effects of this procedure in prolonging life were demonstrated by the Indian Snake Poison Commission. Though it did not prove curative in every case in which it was tried experimentally in dogs, life was considerably prolonged, even in one case up to as much as 37 hours and 50 minutes after respirations had ceased. It is a questionable point whether the destructive processes caused by cobra venom on cells in the medulla, once set up, could be undone by any means, but the chances of antivenene coming into intimate association with the toxin circulating in the blood and anchoring it would appear to be augmented with the prolongation of the interval during which the blood remains circulating. It seems to me probable that in some cases artificial respiration might, in conjunction with antivenene or possibly permanganate of potash injected intravenously, turn the scale in the right direction. The only tests of this procedure that I can trace, were in experiments, where it was not reinforced by other methods, or only in conjunction with Ammonia and agents of a similar nature that have no neutralizing action upon snake venom.

Lastly Lamb has shown that Russell's viper venom, and probably Echis venom do not influence the nervous system. They apparently concentrate their action upon the blood. One of the chief effects produced is the reduction of the coagulability of this fluid, occasioning hæmorrhages which may prove so persistent that death takes place from exhaustion. Setting aside any other possible causes of death resulting from viper poisoning I think there can be no doubt that many of the fatalities arising are directly traceable to syncope from repeated hæmorrhages. At the present time we know of at least one powerful agent in producing increased coagulability of the blood, *viz.*, calcium chloride, and it appears to me possible that a judicious pushing of this drug might in conjunction with other styptics, such as adrenalin chloride do all that is necessary in certain cases of viperine poisoning. I have had occasion to try both in one case, and although it is almost certain that the pit viper, *viz.*, *Lachesis monticola* which inflicted the bite was not a deadly one, the fact that the profuse hæmorrhage which was occasioned by the poison was completely arrested by these drugs seems to point to a possible restoration of the clotting powers when reduced by other viperine poisons.

To sum up I would recommend the following treatment in dealing with snake poisoning cases. Diagnose the case by attention to local rather than general symptoms. In cobra poisoning the intravenous injection of at least 350 (Lamb and Martin now say 100) cubic centimetres of the polyvalent antivenene now prepared at Kasauli. This was the method and dose recommended by Lamb in 1904, and I understand from Colonel Semple that the polyvalent serum now prepared has the same antitoxic value against cobra venom, volume for volume that the old antivenene possessed. Should respirations cease artificial respiration should be practised for hours if necessary.

In all other cases of colubrine poisoning, *i.e.*, the hamadryad, the kraits, the coral snakes and sea snakes, the intravenous injection of 350 c. c. of a 5 per cent. solution of permanganate of potash, with artificial respiration should the breathing cease.

In the case of Russell's viper poisoning the intravenous injection of 350 c. c. of polyvalent Kasauli antivenene, and full doses of calcium chloride to control the hæmorrhages which may be anticipated supplemented with adrenalin chloride, etc.

In all other cases of viper poisoning including the Echis the intravenous injection of 350 c. c. of a 5 per cent. solution of permanganate of potash, with full doses of adrenalin and calcium chlorides. In all cases over and above these special measures, particular attention should be paid to the state of the heart, and if its action is feeble stimulants other than alcohol should be given internally, and, if necessary, hypodermically, and warmth provided either by friction with ginger or mustard, or by hot bottles.

ON SNAKE VENOM AND THE MEANS OF PREVENTING DEATH FROM IT.

By Sir Lauder Brunton, Bt., M.D., LL.D., F.R.C.P., F.R.S.

A consideration of the nature and mode of action of the poison of venomous snakes and of the best means of preventing death from their bite is of the utmost importance in all countries where snakes of this sort exist. More especially is this the case in India where the average death from snake-bite is said to amount to 25,000 human beings annually, and nearly four times that number of domestic animals. The rapid and certain death which follows an injury so trivial mechanically, as the mere puncture from a small tooth, has naturally attracted the greatest interest of mankind from time immemorial. But the scientific study of the cause of death is of comparatively recent origin. There have been a considerable number of workers in this field of research whose labours all deserve much credit; but amongst the most important are Fontana who made the first scientific examination of the action of venom and its antidotes, Prince Lucien Bonaparte who examined its chemical nature, Dr. Weir Mitchell whose investigation both into the physiological action and chemical nature of venom is a model of scientific research, and Sir Joseph Fayrer whose elaborate work on the Thanatophidia of India has so greatly facilitated the task of distinguishing between venomous and non-venomous snakes, and who was the first to make a systematic search for antidotes. To these names should be added those of Calmette and Fraser who have discovered and prepared anti-dotal sera on the same lines as the anti-toxic sera of infective diseases such as diphtheria or anthrax.

There is a marked resemblance between death from some infective diseases and from serpent venom. As noted by Dr. Weir Mitchell in his book on "The Poison of the Rattlesnake," this resemblance was observed by J. L. Mitchell, Gaspard, and others. It is so great as to suggest the idea that the poisons of such diseases are allied in their nature to those of venomous snakes, and indeed this is the case, for we now know that both in the poison of infective diseases and in venoms the active principles belong to the classes of tox-albumins, tox-albumoses, and peptones. Although the course commonly followed in considering a subject like this is to begin with the action of venom upon the animal body, yet it may render this action more easily understood if we preface it by a brief account of the chemistry of organic poisons produced either by the action of digestive juices of pathogenic microbes in disease or by the glands of venomous serpents.

Our knowledge of the chemistry of albuminous bodies is still very imperfect, and I can only give a very meagre outline of it. The substances which were formerly known as albuminous bodies and their allies are now classed under the name of proteins. Those which occur naturally in animals and plants are divided into no less than nine groups some of them containing sub-groups, while the derivatives of proteins form a tenth group containing numerous members. The albumins and globulins form two of the first nine groups whilst derivatives of them such as acid albumin, alkali-globulin, albumoses and peptones are contained in the tenth group.

The researches of Emil Fischer and others on the chemical nature of proteins have shown that they consist, to a great extent at least, of amino acids united together so as to build up huge molecules differing somewhat from one another according to the group to which they belong but all have certain characters in common. Thus we see that the white of egg is not always the same because when cooked it becomes white and opaque in some eggs and bluish and translucent in others. The flesh of all animals is to a certain extent alike, yet it differs in fish, fowl and quadrupeds, and even in the different members of these classes. Without going further into particulars I may say very generally that a huge albuminous molecule so large that it will not dialize breaks up under the influence of strong chemical agents, and especially under the action of organic ferments or enzymes into smaller molecules known generally as albumoses, then into still smaller, known as peptones, and these again into the still smaller molecules of amino acids. This process of disintegration goes on regularly in the digestive canals of animals and the contrary process of building up occurs during the process of absorption and assimilation. As Hermann has put it, when a new house is to be built from the materials of an old one, the walls of the old house are first broken down into the bricks of which they are composed, and these bricks are again built up into a new house. In the same way the proteins either of animals or vegetables are not absorbed as such from the digestive canal, but are broken down into albumoses or peptones before they can be absorbed, and they are again built up into albumins in the intestinal wall or liver before they reach the general circulation. This is fortunate for the animal for the digestive products of albumins are poisonous if injected into the blood but they do not normally enter the circulation as such, being previously converted into harmless albumins.

I may perhaps be allowed to illustrate the difference between the physiological action of harmless albumins, tox-albumins, albumoses and peptones by a very simple comparison, which I have already used elsewhere. An ordinary glass tumbler is quite harmless but if a chip be knocked off its lip a sharp edge remains which may inflict a serious cut on any one trying to drink from it; a tumbler thus damaged may be likened to a tox-albumin. But if the tumbler be broken it will form splinters and pieces of various sizes and shapes, sharp

and pointed, and likely to cause very serious injury to any part of the body with which they come in contact ; these may be supposed to represent tox-albumoses. But just as it may happen that two of them, each dangerous by itself, may be cemented together so as to form a piece having no dangerous point or cutting edge, so toxins and anti-toxins may unite together so as to form a harmless compound. If the splinters be still further broken up they may still be dangerous and represent peptones and some crystalline poisons derived from albumin such as guanidine. But if the glass be ground to a perfectly impalpable powder, it becomes quite harmless and this might represent final products of protein waste, such as urea which are almost destitute of physiological action.

Everyone knows that the breaking up of proteins in the alimentary canal of animals is effected chiefly by the enzymes pepsin and trypsin, which are secreted by the stomach and pancreas respectively. These enzymes as is well known continue to digest albuminous substances outside the body as well as in the digestive canal. The same is the case with microbes which excrete ferments by which they digest the nutritive material on or in which they grow as they are able to excrete ferments having an excess of proteoclastic or amyloclastic power according as the nutrient material is more of a protein or of a starchy nature. In this power they resemble the pancreas of the higher animals.

But in the higher animals the pancreas does not always secrete an active enzyme. On the contrary it secretes an inactive zymogen which yields an active ferment when acted upon by a kinase, or activating substance secreted by the intestine.

The venom of serpents has a triple function, and, although it attracts our attention chiefly from the power it gives to the fangs as weapons of offence or defence, yet its primary use to the snake is that of enabling it to kill its prey and digest it afterwards. The venom in the snake's saliva is secreted by the parotid glands. It occurs in serpents which have no poison fangs and in which its function must therefore be chiefly digestive. It consists of a complex mixture of albumin, globulin, albumoses, peptones and crystalline substances. It does not contain proteoclastic enzymes in large quantities but contains a kinase which renders zymogens and enzymes more active and this accelerates digestion in the stomach and intestine of the snake.

In consequence of the venom containing comparatively little free enzyme it may have little or no digestive action upon muscle when applied alone, but if any other proteoclastic enzyme be present the kinase of the venom greatly increases its action so that the muscle breaks down rapidly.

I have already mentioned that microbes excrete proteoclastic enzyme, and it is probably the increased activity of such an enzyme in the presence of venom kinase, which causes the rapid putrefaction so often noticed in animals dying from snake-bite. At the same time it appears probable that the kinase also activates enzymes or zymogens normally present in the muscles, and thus may give rise to a kind of auto-digestion in them quite apart from the presence of microbes.

The proportions of free enzymes, albumins and globulins, albumoses, peptones, etc., differ in the venoms of different classes of snakes, probably not only in different species, but in the same snake at different times or under different conditions. In consequence of this, differences are observed in the symptoms which they produce, the venom of viperine snakes having a much more marked local action and causing much greater pain at the point of injection than that of colubrine snakes ; both however act as strong local irritants. Cobra poison which may be taken as typical of the venom of colubrine snakes produces chemosis of the conjunctiva and swelling of the eyelids when applied to the eye, and occasionally congestion of the peritoneal vessels when injected into the abdominal cavity. Fresh cobra poison produces great extravasation of blood around the point of introduction, but this is less marked when dried poison is employed. If the poison should happen to be introduced directly into a vein death may occur in a minute or less,* so that there is no time for the development of any local symptoms, but when death takes place more slowly swelling of the part from infiltration of the areolar tissue occurs, and if life be much prolonged, gangrene of the part may occur.

The general symptoms are those of transient irritation succeeded by paralysis of the nerve-centres and motor nerves, and of irritation of the mucous membrane of the digestive canal. The nervous symptoms are depression, faintness, hurried respiration and exhaustion, loss of muscular co-ordination, lethargy and unconsciousness. The symptoms referable to irritation of the digestive canal are salivation, nausea, vomiting and involuntary evacuations not unfrequently of a mucous or mucous-sanguineous character. Death occurs from paralysis of the respiration, and, excepting when the poison has been injected directly into a vein, the heart continues to beat for many minutes after respiration has ceased, and the animal is apparently dead. If artificial respiration be maintained the heart may continue to beat for many hours.

The symptoms of poisoning by the venom of viperine snakes such as Russell's viper resemble in the main those of cobra poisoning, but convulsions are much more marked and appear not to be dependent on asphyxia, but due rather to an irritant action of venom on the nerve centres.

The effects on the coagulability of the blood also seems to differ as the blood is much more frequently found fluid in poisoning by a cobra than by a viperine snake, such as the daboia. After viperine poisoning also there are more frequent exudations of blood from mucous surfaces which may be very extensive. If the dose of poison is too small to kill the animal it usually recovers perfectly from the effects of the cobra venom but this is not the case with that of other snakes. Four and

* Brunton, Fayrer op. cit.

twenty hours after daboia poisoning an animal may lose its appetite, get diarrhœa and albuminuria, and die exhausted after some days, or more quickly from œdema of the lungs or general hæmorrhages into various organs. In the case of bites from the bungarus fasciatus a different set of symptoms is produced such as loss of appetite, great weakness, rise of temperature, albuminuria and discharge of pus from the eyes, nose and rectum but no tendency to hæmorrhage. It seems strange at first sight that the viperine poisons should appear to have anti-coagulant properties when Calmette in his work on Venoms divides venoms into two classes, coagulant and anti-coagulant, and puts into the coagulant class the viperine venoms which are precisely those in which the blood of animals killed by them is usually fluid. These effects depend not only upon the different kinds of venom but on the amount that is acting, and in this respect they agree with albuminous bodies obtained from granular organs and also with the products of digestion.

The watery extract of the testis and thymus glands of the calf will, when injected into the veins of an animal, produce instant death from wide-spread intravascular clotting, but, when death occurs, the blood which flows from the cut arteries refuses to coagulate, and, when the quantity injected is insufficient to kill, the blood drawn off after injection may remain uncoagulated for some days and the injection of albumoses of commercial so-called peptone will prevent coagulation in the blood of a dog or cat. Something evidently depends also upon the animal because these effects are produced very rarely, if at all, in rabbits. If we attempt to analyse the effect of snake venom on different organs I think it will be found it has got a destructive action on nearly every one. It acts however more especially on the respiratory centre, on the grey matter of the spinal cord, on the ends of the motor nerves, on the stomach and intestines, and, in the case of viperine poisons, on the blood vessels. The respiratory centre is at first excited and afterwards paralysed. The viperine poisoning seems to excite the medulla or spinal cord and produce convulsions by acting upon it directly, while those which occur from cobra bite are chiefly due to asphyxia and may be arrested by artificial respiration. The ends of the motor nerves are partially paralysed as well as the spinal cord and this leads to a local paralysis of the part bitten. The vomiting is probably due to excretion of the poison by the gastric mucous membrane in the same way as tartar emetic is excreted, and, when locally applied to the stomach of a frog, it may cause such intense irritation as to produce vomiting in that animal, which very rarely occurs indeed.

The hæmorrhages which are produced by serpent venom appear to be due to alterations in the capillary walls. When Fayrer and I examined the process by applying cobra venom to the mesentery of a frog under the microscope, extravasation took place so rapidly that we were unable to follow its mechanism, but Weir Mitchel and Reichhardt observed that the wall of the capillaries appeared to become ampullated before bursting. The muscles become soft round the part bitten and putrefy quickly. The softening may probably be caused by a snake kinase which produces self digestion, and the ready putrefaction may also be due to a further stage of the same process or it may also be caused by the softened tissue becoming infected by microbes. The general resemblance between the effects of all serpent venoms as well as the differences between those of different genera and species are precisely what one would expect from a combination of different albuminous bodies and their derivatives, much in the way that I have tried to explain by the illustration of broken glass in an early part of this paper. They also agree with and at the same time differ from the toxic bodies formed in the process of digestion or by various pathogenic microbes. They agree with these however in this curious property, that when injected into the animal body in too small a quantity to produce a serious result, they cause the body itself to form antagonistic substances, not only in quantity sufficient to counteract the effect of the small dose injected, but many times greater. So, as was shown by Sewell, after the first dose has been recovered from, a second, which would cause certain death, in an unprotected animal, may be harmless. By successive injections of increasing quantities of venom the resisting power of an animal may be raised to fifty times its normal, and if the serum of such a resistant animal is injected into another one which has already been poisoned, either by inoculation or by the actual bite of a poisonous snake, be prevented, the action of the poison may be entirely prevented or may be arrested when it has already proceeded to a considerable extent.

It is evident that such a serum, which has been prepared by Calmette is of the utmost value, and I have myself seen two rabbits poisoned at the same time with cobra venom by Calmette himself. After the symptoms had progressed to a certain extent in both he injected his antidotal serum into one. Further symptoms were arrested in the animal thus treated and it recovered, while the other died in a short time in the usual way. I believe that Calmette was himself bitten by a venomous snake in his own Institute and would probably have died but for the prompt use of the antidotal serum. About the value of this method there cannot possibly be the slightest doubt and in all stations where it is possible a supply of serum might be kept and used should occasion arise. One objection to this is that if a horse has been immunised by colubrine poisoning it does not antagonise viperine, and *vice versa*, but this difficulty has been met by immunising the horses to both kinds and thus preparing a polyvalent serum. It is at present also uncertain how long the serum will maintain its activity in a hot country like India, but this is a matter which I think ought to be settled by experiment on animals because it would not do to wait until a case of cobra or viperine poisoning occurred and then find out that the serum to which one trusted to save the patient was useless. The greatest difficulty of the serum treatment however is that it can only be applied at stations, and

by men possessing a certain amount of skill, and before the bitten man or animal reaches such a station death is likely to have occurred.

Sir Joseph Fayrer tried injecting a solution of permanganate of potash into the veins as an antidote to cobra venom but found it useless when applied in this way. In 1877 Wynter Blyth found that permanganate of potash when mixed with cobra poison in vitro completely destroys its activity and early in the following year Sir Joseph Fayrer and I confirmed this result as well as that of Pedler, that chloride of platinum would also destroy the poison. We tried also liquor potassae, chloride of zinc, nitrate of silver, ferric chloride, mercuric chloride and carbolic acid but found these, though sometimes lessening the effect of the poison, did not prevent its lethal action. Chloride of gold we found however to have a similar action in destroying the poison as chloride of platinum. We had just begun to try whether we could prevent the action of the poison after it had already been injected and we accordingly injected a solution of permanganate of potash into the tissues around the point where the poison had been applied. These experiments gave a negative result and their further continuance was prevented by the Antivivisection Act. The experiments were however continued by Mr. Vincent Richards who was more successful than we and found that the hypodermic injection of a watery solution of cobra venom was followed, even at as long an interval as four minutes, by a similar injunction of permanganate of potash, no symptoms of cobra poisoning resulted. After the symptoms had developed permanganate of potash, however applied, had no effect.

The question was again taken up by Major Leonard Rogers who confirmed and extended these results, and showed that when a ligature was applied to a limb immediately after injection of the poison, and incision then made at the point of injection and crystals of permanganate of potash placed in the opening and rubbed in with some water or saliva the effect of the poison was destroyed. He also showed that the permanganate was equally efficacious as an antidote to colubrine and viperine snakes.

We may look then upon permanganate of potash as a complete antidote to snake venom if it is quickly applied, in sufficient quantity and in the proper way. But for this purpose it is necessary to have an instrument which is cheap, easily carried about and not liable to get out of order and can be used without an instant's delay.

Hypodermic syringes are expensive. They are difficult to keep in order and just at the very moment when it is most important that they should act it may be found that the piston has become dry and simply moves idly up and down in the syringe so that no injection can be made.

To meet these requirements I have devised a small lancet set in a wooden handle which is hollow so as to contain permanganate of potash. Both ends are covered by a cap. The cap covering the lancet is the bigger of the two so that it is almost impossible to mistake them but if any difficulty is apprehended on this point it is easy to stain the permanganate end by simply wetting the end and smearing the crystal over it. The mode of application is to tie something tightly over the limb above the bite, a strip torn from the clothing being the most likely thing to be at hand. The punctured wound of the bite must then be converted into a clean cut and the permanganate thoroughly well rubbed in and moistened with a little saliva or water if this be at hand. For safety's sake it may be well to make some lateral cuts so as to reach any poison that has begun to be absorbed. It is much to be wished that such an instrument could be made more cheaply than at present, for though the price, six pence, may seem very low to a European it will seem very high to a native. If cheap instruments could be sold at all stations where quinine is at present sold, it would place in the hands of the natives a very valuable means of protecting both their own lives and that of their cattle.

FURTHER RESULTS OF THE LOCAL PERMANGANATE OF POTASH TREATMENT OF SNAKE BITES.

By LEONARD ROGERS.

The discovery of an antidotal serum against cobra venom by Calmette, independently confirmed by Fraser, opened up visions of a reliable and practical method of reducing the great mortality from poisonous snakes in India and elsewhere. Lamb in his earlier work on the standardisation of Calmette's serum advised 40 c.c. to be administered subcutaneously, basing his estimate on the amount of venom Calmette obtained from cobras imported into France. Unfortunately, D.D. Cunningham had previously shown that the amount of venom obtainable from fresh cobras in Calcutta was six times as great as Calmette's estimation, and further observations I made confirmed Cunningham's figure. Thus, the dose of antivenine necessary to neutralise a full dose of cobra venom amounts to several hundred cubic centimetres, as Lamb now acknowledged. Moreover, I showed that even full doses were practically useless when given subcutaneously in animals, but when administered intravenously they acted just as if previously mixed with the venom before injection. C. J. Martin had previously found that about ten times as much serum was required subcutaneously as intravenously. Moreover, it has been shown by independent experiments

of Lamb and myself that anti-cobra venom has only a very slight, and practically unimportant, action against the venoms of other colubrine snakes, and none at all against those of viperine, so that either separate serums must be stocked against each poisonous snake, or a polyvalent one is necessary. Lamb has now made one which is active against the two commonest Indian poisonous snakes, namely the cobra and Russell's viper, which should be of great value, if available by the intravenous method in very large quantities in a fresh active condition (for it gradually loses its strength in the hot weather) and should the case happen to be one due to the bite of one of these two snakes. Unfortunately, this is such a large "IF" that the beautiful completeness of the scientific basis of the serum treatment for snake bite is sadly marred by its impracticability in the infinite majority of cases occurring in actual practice in India.

Fortunately we have an alternative method of destroying the venom locally before a fatal dose is absorbed, which is not only of great practical value by itself, but also renders the serum treatment of more actual value by greatly reducing the doses required of this expensive and badly keeping remedy, for the amount of poison requiring to be neutralised in the blood in such cases as come too late under treatment for the entire efficiency of the local treatment will be much reduced by the destruction of any unabsorbed venom.

I have already published two series totalling 13 cases in which the snake which bit the patient was actually obtained and identified, thus leaving no doubt as to their genuineness, with only one death in an already moribund patient. The method has come into such universal use in India that cases are now seldom reported to me, but the following table includes subsequent ones in which the snake was caught and identified, although numerous other cases without such complete proof have also been sent to me.

Snakes.	Cases.	Recovered.	Died.	Total.
Cobras	12	11	1	13
Kraits	3	3	...	3
Russell's viper ...	4	4	...	4
Viper (2 kinds) ..	1	1	...	1
Pit viper ...	1	1	...	1
Total ...	21	20	1	21

It will be observed from the above table that the list includes cobras, kraits, Russell's vipers and one of a pit viper, which is probably rarely fatal in the human subject. Colonel A. Buchanan, I.M.S., also informs of a successfully treated case of Echis Carinata bite. This confirms my experiments showing that this drug has the invaluable advantage of acting equally well against all classes of snake venoms. The whole series, including those previously reported by me, may be conveniently summarised in the following table.

Table of further cases of snake-bite treated by local applications of Permanganate.

No.	Race.	Sex.	Age.	Snake.	Site of bite.	Time before treatment.	Ligature.	Antivenine serum used.	Result.
1	M	M	7	Cobra ..	Finger.	..	Ligature after 5 minutes	Nil ...	Recovered.
2	M	F	30	Krait, common.	..	..	At once.	Nil ..	"
3	..	..	..	Viper	..	1½ hours	..	Nil ..	"
4	N.Ch.	M	25	Krait, common.	Finger.	1 hour	At once.	Nil ..	"
5	H	M	20	Cobra ..	..	1 "	..	Nil ..	"
6	H	M	45	Cobra ..	Finger	1 "	At once.	20 c.c .. subcutaneously.	"
7	M	M	25	Krait (young).	"	1 "	"	Nil ..	"
8	H	M	Adult	Russell's viper.	"	1 "	..	Nil ..	"

The only fatal case in the series was one treated 11 hours after the bite when moribund. Even if we allow that successful cases are more likely to be reported than failures (and I have heard verbally of one failure of which I have not any detailed record), still the above results are strikingly favourable, and more than bear out in the human subject the hopes I based on my experimental demonstration of the efficiency of the method in animals.

As it is only exceptionally that undoubted cases, verified by the snake being caught and identified, are obtainable, the results got in a consecutive series of 18 cases of snake-bite treated in the Banda District of the United Provinces are worthy of mention. I am indebted for them to the kindness of the Honorable Colonel R. D. Murray, I.M.S., Inspector-General of Civil Hospitals, United Provinces. Of these 18 cases treated by the permanganate method and without any serum, 17 recovered, while the one patient who died did not come under observation until some hours after the bite and when in an unconscious condition. It is scarcely conceivable that the other 17 cases had all been bitten by non-poisonous snakes or that none of them had received a fatal dose, so I think they may be considered to supplement the evidence derived from the undoubted series tabulated above.

As Major Lamb states that by this method "in practise it can only be by accident that the permanganate reaches the poison, which may be deeply placed in the areolar tissue and at some distance from the punctures," it may be well to repeat my previously recorded observation that in animals an effusion of blood stained fluid occurs very rapidly at the site of injection of the poison which enables its position to be at once located, and to add that, in one case treated by me within a few minutes of the bite, this sign was already present in the human subject. Moreover the fangs of colubrine snakes can hardly penetrate more than half an inch, while with Sir Lauder Brunton's lancet there is no difficulty in incising to the bottom of a Russell's viper bite, which might possibly penetrate as much as one inch. A few trifling incisions need not be weighed in the balance against the terrible danger of death from snake poison.

Yet, again, from an analysis of 35 cases of which I have notes, I find that in just three-fourths of them the bite was on the hand or foot (nearly invariable on the dorsum of the foot or ankle in the latter), that is, in a part where there is no great depth of tissue to cause trouble in localising the site of the poison.

Now that the snake lancet is becoming more and more widely distributed throughout India, and the value of the local destruction of the venoms with permanganate of potash is very generally recognised, something practical is being done to lessen the mortality from snake bites in India, and at last the patient researches of the late Sir Joseph Fayrer, and Sir Lauder Brunton, and other workers too numerous to mention are beginning to bear fruit.

DISCUSSION.

Major A. Hooton, I. M. S., said :—We have it on the best authority, that of Sir Lauder Brunton, the late Sir Joseph Fayrer, and Major Rogers, that permanganate of potassium destroys the activity of snake venom, and it is far from my object to attempt to minimise the usefulness of the lancet which goes by the name of Sir Lauder Brunton when other more effectual means are not available ; but it has already been pointed out by Major Wall that a thorough dissection of the tissues surrounding the fang puncture is necessary to ensure that the antidote shall come in contact with the venom, and it is with the purpose of emphasizing this that I place on record the following two cases. To begin with I may state that 41 other cases of snake bite have been reported from various dispensaries in Kathiawar, since the Brunton lancets have been issued, all of which, with the exception of 4, were treated with permanganate after ligature. Of these 4 one died and 3 recovered, while of those in which permanganate was applied one also died. In none of the 41 cases was I satisfied as to the identity of the snake.

On the other hand, I have, what I regard as very reliable, records of the following :—

(*a*) A boy aged 12, who had turned on a water tap which communicated with an underground channel, and placed his hand over the other end of the channel to ascertain if the water was flowing, was bitten by a cobra on the right index finger about its middle. He was attended by Mr. Govarishanker, a most trustworthy Hospital Assistant, 10 minutes afterwards, and a crucial incision was made over each puncture after the application of a ligature round the arm Permanganate was then rubbed thoroughly into the wounds, and a stimulant mixture given.

With the exception of local pain the boy appeared none the worse, and his condition remained satisfactory until $2\frac{3}{4}$ hours after the bite, when the tourniquet gave rise to so much distress that it was removed. Fifteen minutes afterwards nausea and vomiting set in ; these symptoms were followed by drowsiness and coma, and the patient died 4 hours after the ligature was relaxed.

(*b*) For the details of this I am indebted to Major Roberts, I. M. S., of Indore.

A boy, age unknown to me, was bitten on the ring finger of the right hand, near its base, by a large krait ; a Hospital Assistant was called at once, and applied a ligature, scarified the part and rubbed in permanganate crystals. Two hours afterwards the ligature was removed, there being no symptoms, but two hours later (4 hours after the bite occurred) Major Roberts, having been called, found the case practically hopeless. Antivenine was injected, and a ligature applied again, but death occurred from respiratory failure in a very short time. I quote these examples for what they are worth, and with the knowledge that some successful instances of the permanganate treatment are on record. Personally, I am forced to two conclusions : in the first place, I shall always advise amputation for the bite of a known poisonous snake in a finger, and, further, I shall have very little faith in the application of permanganate except under an anæsthetic, or without it, after very thorough dissection, a procedure which a layman, or the average Indian dispensary medical officer, is not likely to be prepared thoroughly to carry out.

Major Lamb, I. M. S., said :—In Sir Lauder Brunton's paper there is strongly recommended a method of treatment of snake bite by incision and rubbing in of crystals of permanganate of potassium. For this purpose he has devised a small lancet enclosed in a wooden case, which case also contains a receptacle filled with crystals of permanganate of potassium. Let us for a moment briefly summarise the evidence which has in recent years been put forward in support of this much advertised method of treatment. First, it has been conclusively shown that permanganate of potassium, when brought in contact "in vitro" with snake venom destroys the poison, rendering it innocuous when injected into the animal body. This fact cannot be denied.

Secondly, in a few experiments made in London by Major Leonard Rogers, I. M. S., it was shown that under the conditions of experiment used a certain proportion of animals was saved. But the conditions of experiment were very different to those that obtain in nature. A solution of the poison was injected under the skin by means of a hypodermic syringe, only a small multiple of the minimum lethal dose being employed. Now it was long ago pointed out by Wall that, when a snake bites, the poison is deposited not in the skin itself but in the areolar tissue beneath and that as the skin is as a rule freely moveable over the parts below the fangs may have dragged it away from its proper position before the poison is injected. In this way it happens that the poison is not deposited immediately beneath the punctures. Major Rogers in his experiments, which were made on cats, knew accurately the direction taken by the point of the needle and in planning his incisions was able to follow the poison and thus get the permanganate in contact with it. It is, therefore, not surprising that he found the method succesful. It was then promised that on his return to India similar experiments would be done, live snakes being used in place of a hypodermic syringe. The publication of the results of these experiments we still await.

Thirdly, several cases of snake bite in man have been treated by this method with apparently most happy results. But evidence of this kind must be received with the greatest caution. For the snake may not have been a poisonous one and if a poisonous one a lethal dose of venom may not have been injected. I have known a case of bite from a lizard treated with Calmette's serum and claimed as a success, the symptoms described being those which are observed to follow cobra bite. It is also not uncommon for persons to recover after being bitten by a snake even after symptoms of a grave nature have developed.

It seemed necessary, therefore, again to test experimentally this method of treatment, employing conditions which approached as far as possible to those which would obtain in nature. I have recently done so in the laboratory at Bombay with results which, as we shall see, throw much doubt on its efficiency. The experiments were as follows :—

A black spectacled cobra was allowed to bite three monkeys in succession. This cobra had been received five days before from Khandwa in the Central Provinces. It was of medium size, weighing 300 grammes and measuring 3 ft. 10 inches. The poison had not been extracted. It was held in the hand of a snake man and allowed to bite the lower leg of each monkey. The details were as follow.

Monkey 1. Weight 3·25 kilos. Bitten at 1·7 p.m. : the snake bit twice over the same position. There were four distinct punctures situated close together. A tight ligature was *at once* applied just above the knee. Deep longitudinal incisions with the regulation lancet were then made through each puncture and at the same time small lateral

incisions, as recommended by Sir Lauder Brunton, were run into the longitudinal cuts Permanganate of potassiu mcrystals, the whole contents of the hollow of the lancet case being used, were immediately put on the wounds, moistened with water and well rubbed in with the fingers. The whole operation was completed at 1-10 p.m. three minutes after the bite. The bandage was not removed till 1-17 p.m.

At 1-27 p.m.	There was marked ptosis and the animal appeared ill.
,, 1-30 p.m.	Paralysis was marked and
,, 1-35 p.m.	Was almost complete.
,, 1-42 p.m.	Breathing stopped, namely 35 minutes after the bite and 25 minutes after the bandage had been removed.
Monkey 2.	Weight 1 55 kilos. Exactly the same procedure as in the previous case. The snake only bit once and there were two distinct fang marks.
At 1-16 p.m.	Bitten.
,, 1-19 p.m.	Operation completed.
,, 1-29 p.m.	Ligature removed.
,, 1-49 p.m.	Slight ptosis.
,, 1-56 p.m.	Staggering.
,, 2- 6 p.m.	Lying down paralysed.
,, 2-11 p.m.	Died, namely, 55 minutes after the bite and 42 minutes after the ligature was removed.
Monkey 3.	Weight 3 kilos. Exactly the same procedure as in the first case. The snake bit once, and there were two well-marked punctures.
At 1-45 p.m.	Bitten
,, 1-48 p.m.	Operation completed.
,, 1-59 p.m.	Ligature removed.
,, 4-7 p.m.	Ptosis and staggering.
,, 5 p.m.	Died, namely, $3\frac{1}{4}$ hours after being bitten and 3 hours after the ligature was removed.

I should especially draw attention to the following points in these experiments:—

1. The same snake, a small one, was used for all three monkeys. It bit four times—twice on the first monkey - in the space of 38 minutes.
2. The ligature was applied at once and the whole operation was completed within 3 minutes after the bite. The site of the ligature was just above the knee, a position where there is only one bone.
3. The ligature was left on for from 10 to 15 minutes after the operation had been completed.

It is evident, therefore, that the conditions of these experiments were most favourable for the success of the treatment, much more favourable than would ever occur in nature. Still it failed in every case. The longer prolongation of life of the second and especially of the third monkey is no doubt to be explained on the basis of the smaller amount of poison injected, the snake having already partially emptied its glands. It cannot be claimed for the treatment. It would appear, then, that the claim put forward for this method of treatment by Sir Lauder Brunton is not likely to be realised in nature and that as a means of destroying the venom locally much more reliance should be placed on free dissection, followed by swabbing out of the wound with a strong solution of permanganate of potash as originally recommended by Wall.

Dr. Arthur Powell passed round for inspection specimens of "Snake lancets" sent by Sir Lauder Brunton, made by Messrs. Ferris of Bristol and Arnold of London. He read the following extract from a letter just received from Sir Lauder.

"The late Sir Joseph Fayrer has asked the Secretary of "State for India to have these lancets on sale at all stations "where quinine is sold in India, but the Government of India "negatived the proposal I have written to the India Office "here renewing the request and have pointed out that, when "Sir Joseph Fayrer made it, the method of treatment was still "untried. The price of sixpence which is the cheapest at which "Messrs. Arnold can supply the lancet is, I think too high for "the Hindoos, but if the Government of India would either give "an order for £100 worth yearly for ten years—which I think "is less than the salary of a single official these lancets might "be manufactured at either a penny or a halfpenny each, and if "they were sold in every small station, the Government would "practically get most of its money back. Perhaps if they were "made in a Government small arms factory, they might be "turned out for even less My request has been sent on by "the India Office to the Government of India, but if it were "backed up by a resolution of the Bombay Congress, it would "probably go far to make the Government arrange for a wide "spread sale, or even distribution of lancets. Surely every "soldier in India at least, should be provided with one."

Dr. Powell personally failed to see why Tommy Atkins should have these "Snake-lancets" lumbered on to him. What was the chance of the European soldier dying of snake-bite? He was under the impression that not a single one had died for about twenty years There was far greater risk of death from lightning-stroke, but no one proposed the soldier's kit should include a lightning conductor. Further, he considered the issue of the lancet as pernicious, in that a popular belief had gone abroad that there was some special virtue in the lancet, which at the best was a tinkering instrument, certainly not an instrument, for a Surgeon. Yet Major Rogers informed him that in many of his cases it was used by qualified medical men. He knew even officers of the Indian Medical Service carried these tools with them. A scalpel, or a pocket knife, was a much better and more surgical instrument.

The principle that guided the Surgeon in treating a benign growth, was to remove the tumor, the whole tumor and if possible, nothing but the tumor. In Snake poisoning, as in Cancer, the last condition was impossible, but the Surgeon's clear duty when he met a man bitten by a venomous snake was, after ligature, to remove as large a lump of the surrounding flesh as was possible without causing too great deformity. A digit should be amputated, a good "steak" cut from calf, thigh or arm. The tendons of the foot, the muscles of the thenar or hypothenar eminences should not be spared. It was impossible to do more than scratch with the instruments handed round.

Dr. Powell had always carried his principles into practice with success, and usually found when the snake was afterwards produced that it was a harmless one.

He had no objection to the soldier carrying the permanganate of potash with him. He could devote it to more than one prophylactic purpose. In the injection of antivenene he would strongly urge the employment of the intravenous method. It was generally supposed that this was difficult of performance, and required a certain amount of skilful dissection. It is by no means so. It is wonderfully easy to insert a hypodermic needle in one of the veins of the forearm when the latter is compressed proximally. A free flow of blood from the needle is evidence that its point is free in the lumen of the vein. The filled syringe should then be attached and the serum injected.

Major Lamb found fault with Roger's experiments in London, "only a small multiple of the minimum lethal dose being employed." Lamb's experiments erred as much on the other side, and could not be compared with what would occur in man in nature. Lamb employed small monkeys,—from $1\frac{1}{2}$ to $3\frac{1}{4}$ kilos in weight Say one-fortieth to one-sixtieth the weight of the average native man. Lamb's experiments, if translated into equal doses per kilo for man, would require the man to be bitten by from sixteen to forty cobras ! ! "Conditions of experiment very different to those that obtain in nature." He presumed Sir Lauder's objective was not to save the lives of monkeys.

Major L. Rogers said:—Major Wall stated that no snake venom causes syncope. This is true as regards the direct action on the heart, but I showed several years ago (Phil. Trans. of the Royal Society, 1904) that all viperine snake venoms produce failure of the circulation through vaso motor paralysis I have tried intravenous injections of permanganate salts, but found the potassium one too poisonous, while the sodium one was precipitated on boiling to sterilise the solution. Artificial respiration is a valuable measure in colubrine poisoning, but once the respiratory centre is completely paralysed it is of no avail. On the other hand I cannot agree with Major Wall when he says antitoxic sera can be of no value once symptoms have set in, as given intravenously in proper doses I have saved animals after marked symptoms of paralysis have occurred, the controls dying, and nothing is so striking as the rapid and complete recovery from almost complete paralysis caused by sub-minimal lethal doses of colubrine venoms.

With regard to Major Lamb's single experiment with three monkeys bitten successively by a cobra, I would point out that according to Lamb's own estimations the first monkey would have received several hundred times a fatal dose, and the others an unknown but relatively very large quantity, probably from 50 to 100 fatal doses, such as rarely if ever occurs in man. In my experiments I saved animals after injecting up to ten lethal doses, but stated that, in such, treatment would have to be very prompt, but have never suggested or thought that such enormous doses as Lamb used could be neutralised before one fatal dose had entered the circulation. Moreover, his bites were inflicted into the muscles of the animals, while I have shown that this can very rarely occur in man. In my directions I advised a two-inch incision, and dissection up of the edges of the wound, which is sufficient in ordinary cases, but I quite agree with Dr. Powell that there is no objection to still freer incisions being made. The cases I have recorded prove that the method has often been successful in undoubted cases, while it is practicable under ordinary Indian conditions. Dr. Powell says the instrument is not one for Surgeons to use. It was not intended for Surgeons, but for laymen, who alone are likely to be immediately available in most snake bite cases in India.

A NOTE ON ACTINOMYCOSIS IN INDIA.

By Major HOOTON, I.M.S.

The remarks I have to make are based on two cases which were treated in the West Hospital, Rajkot, during the past year. Case 1 was a man of 37 years, a Hindu, and by occupation a clerk.

Three months before admission he first began to suffer from cough, with bloody expectoration, and about the same time he noticed a small swelling in the left submaxillary region, which shortly afterwards became soft and broke down. There was a history of syphilis 15 years before. On admission the most noticeable feature was a tumour of a very peculiar appearance situated over and firmly adherent to the left horizontal ramus of the lower jaw, about midway between the chin and angle; the growth was the size of half a duck's egg, split longitudinally, and with the convexity outwards, of a firm, somewhat elastic texture, with a pale, rough, ulcerating surface which I can best describe as resembling discoloured cotton wool. The discharge was fairly copious, and very offensive. There was also a small, ill-defined swelling in the left infra-clavicular region, and, on examining the chest, pneumonic patches were discovered in the left infra-scapular region, and over the right apex in front. He suffered from cough, with a remittent temperature, and brought up a muco-purulent expectoration, which at times was tinged with blood. It struck me that actinomycosis would best account for the symptoms, and I examined the pus and sputum, but without finding any typical filaments.

Potassium iodide was administered, and the growth excised, but, except for a temporary improvement in the chart which succeeded the operation, the symptoms were not appreciably relieved, and the patient left the hospital and eventually died.

Instructions had been given to preserve the tumour for transmission to the Parel Laboratory, but it was unfortunately placed on a table in the verandah for a few minutes, and stolen by a crow. The second case was a man of 20 years, also a Hindu, a beggar. Six months before admission he noticed a swelling over the right side of the lower jaw. He applied native medicines, and the growth increased in size and eventually burst. On admission there was a marked swelling below the middle third of the right horizontal ramus which at first sight suggested an alveolar abscess, but the teeth were sound, and, on examination, a hard brawny mass was found, which extended deeply into the submaxillary region. The surface of the growth was pierced by 5 sinuses, three of which extended into the substance of the bone which was markedly carious. The sinuses discharged a small quantity of very offensive pus, from which, after several unsuccessful attempts, I managed on one occasion to isolate 2 or 3 greenish nodules, about the size of a pin-head, or smaller. On crushing one of these a film was obtained which, on staining with carbol fuchsin, showed a typical mycelial tangle.

An interesting feature of this and all the other films I made from the discharge was an apparently accidental infection by two other organisms; the field was crowded, almost always, with spirilla, and amongst the spirilla was a smaller number of stouter organisms, varying from half to about the same length as the spirilla, with pointed extremities, and no spiral turns. In a fresh specimen these stood out very markedly from the others, moving in a curious diving or plunging manner. Dr. Stephens, of the Liverpool Tropical School, to whom I sent some specimens, informs me that both spirilla and the other organisms have been previously described in suppurative processes in the neighbourhood of the mouth (*e.g.*, Cancrum oris), the latter under the name of spindle bacilli.

In this case there was no history of syphilis. The sinuses were freely opened and scraped, although, having regard to their awkward situation, no attempt was

made at entire removal of the growth, and large doses of iodide were administered. Under this treatment he made an extraordinarily rapid recovery, and was eventually discharged, apparently completely cured.

On referring to all the Indian medical literature at my disposal I am unable to find any reference to actinomycosis, and this, coupled with the fact that up to the present I had never come across any cases, induced me to think that the subject might be of sufficient interest to bring forward. Mr. Sowerby, the Principal of the Bombay Veterinary College, informs me that, so far as he knows, the disease is not common amongst animals in India, and that at the Bombay Veterinary Hospital there is only about one admission a year for it. Considering the close resemblance of actinomycosis to mycetoma this is not what one would expect, and the question arises whether it may not have been overlooked to some considerable extent. It is worthy of note that mycetoma is prevalent in the Province of Kathiawar. As regards the microscopic diagnosis of actinomycosis it is not, apparently, always a simple matter. In looking up references I have several times come across the remark that the mycelium is often very difficult to find, and my own experience bears this out. In the second case quoted I did discover it, but only once out of several dozen preparations, and in the first, which I am personally convinced was also due to the same disease, I entirely failed.

When found, the filaments closely resemble those of mycetoma, but are rather finer ; so far as my experience goes it is useless to search for them haphazard in the pus and only an examination of the typical small nodules is likely to be successful. Clinically it is obvious that the disease might be confounded with several others, and perhaps most easily with a chronic alveolar abscess, accompanied by much thickening and perhaps extensive periostitis. Mycetoma would no doubt be easily distinguishable, as a rule ; I have so far never seen the disease in any other region than the foot, and, although it affects the hand occasionally, its occurrence in the jaw, if it attacks that part at all, must be very rare indeed. The naked eye appearances of mycetoma are also usually very characteristic, especially on section, and it is said to be unaffected by potassium iodide, in sharp contrast to actinomycosis, which often reacts in a most remarkable way to that drug ; not less in animals than in men, I believe. A further point of distinction would be the tendency of actinomycosis, to form metastatic deposits, and the fact that it never affects the lymph glands, as compared with mycetoma, which never becomes generalized, but does, on the other hand, occasionally involve the lymph glands.

THREE CASES OF ACTINOMYCOSIS.

By ARTHUR POWELL.

On my first arrival in India among the cases in the Western Cachar Company's Hospital, of which I took over charge, was one which the Hospital Assistant had diagnosed as "Carbuncle." Except that there was very little pain, and the inflammation was far from acute, a superficial examination would have excused the diagnosis. The fact that the lesion had existed for at least five months, raised in my mind a suspicion of Sarcoma.

At this time, I had never even heard the name Actinomycosis, and the literature at my disposal referred to Mycetoma as a disease limited in situation to the feet.

Case I.

Male, Hindu, coolie, aged 25, first seen on July 4th, 1888, somewhat emaciated, showed on the chest wall external to and below the right scapula an oval raised tumor about $3\frac{1}{2}$ inches long by 3 inches broad, perhaps $\frac{3}{4}$ high in the centre. Several sinuses discharged a sticky pus which later on was observed to contain numerous round concretions about the size of a pin head. Similar bodies were occasionally coughed up in the sputum. My first diagnosis was Sarcoma, but on noticing these bodies I was struck with the resemblance to the disease of which I had read as "Madura Foot," but which in my ignorance I thought was confined to the lower extremities.

Microscopic examination of these bodies showed a mycelium which appeared to confirm my diagnosis of "Madura Foot of the Thorax."

In August the discharge became much greater, the sinuses opened into larger cavities, cough and expectoration were greatly increased. I accordingly made an attempt to remove the growth, partly by cutting, but chiefly by the sharp spoon and gouge.

A considerable length of the 7th rib was carious and came away easily with the gouge, which then entered what appeared to be the solidified and adherent lung. Several pockets of pus containing characteristic "concretions" were cleared till hæmoptysis set in, sufficiently profuse to make further administration of chloroform unsafe. Owing to adhesions no air entered the pleural sac. The cavity and the wound were then packed with iodoform gauze.

A considerable improvement took place in the ensuing couple of months, partly no doubt owing to the free use of iodoform and the fact that the Hospital Assistant, owing to a fortunate misunderstanding, administered 30 grains of Potassium Iodide daily.

The extrapleural tissues granulated and contracted till instead of a raised tumor there was a puckered depression in which three sinuses still remained, discharging a small quantity of nodule—containing pus from the lung.

The patient improved considerably and put on flesh,

but left Hospital with these sinuses still discharging. The sputum then contained no concretions.

I heard of his death in his "busti" about a year later, from a renewal of the growth.

Microscopic examination of the nodules showed a copious mycelium but no clubs in the stained specimen though many of the rods appeared thickened at the ends in fresh preparations.

A portion of the excised growth was sent to Allen Macfadyen who reported it as unmistakable Actinomycosis.

Case II.

In March 1897, Bengali, female, aged 47, with several sinuses discharging on the skin over the right side of the lower jaw, inner aspect of the cheek, and gums in the neighbourhood of the right lower premolar and first molar teeth.

Her chief complaint was that the "bhat" she ate used to accumulate in the sinuses and discharge on her cheek. The illusion was almost justifiable as the pus contained numerous granules in appearance and consistence remarkably like small pieces of yellowish cooked rice.

An examination of the granules showed typical Actinomyces mycelium, with which and the literature of the disease I had then made myself fairly familiar at the British Institute of Preventive Medicine.

The probe on entering the sinuses showed a considerable portion of jaw carious. This was thoroughly gouged away, the sinuses well scraped and stuffed with iodoform gauze. Considerable improvement ensued, but three months later fresh sinuses appeared. These were thoroughly scraped on three occasions, and some months later the patient was seen with the sinuses healed and quite cured except for the unsightly scar.

Case III.

A Bengali, male, aged about 25, presented symptoms, signs and history remarkably similar to the previous case including the complaint that "bhat" used to escape from the sinuses.

Under chloroform an attempt was made to gouge out the diseased tissue, in doing which the carious ramus of the jaw gave way. The diseased portion with the two premolars and first and second molars was then excised with the surrounding soft tissues.

The whole disease appeared removed and no further granules were seen for three months, by which time the wound had healed leaving a very ugly deformity of the jaw.

A sinus then opened inside the cheek, discharging a few granules, the patient refused further treatment being highly chagrined at the by no means cosmetic result of the first operation.

The removed tissues, except that no clubs were seen in the stained specimen, were characteristic of Actinomycosis.

The subsequent history of the patient I am unable to trace.

LATHYRISM.

By Lieut.-Colonel A. BUCHANAN, I.M.S.

In the years 1896 to 1902 there was a severe epidemic of Lathyrism in the northern parts of the Central Provinces. A census taken showed that there were 7,600 cases. A full report was published in 1903 and the following are a few of the principal points :—

Cause.—That the disease is caused by Lathyrus is proved as follows :—

(*a*) The disease usually follows famine or scarcity, and it is only when other food is scarce that lathyrus is eaten in large quantities.

(*b*) It occurs chiefly in areas in which lathyrus is grown in large quantities : the rice districts are an exception to this rule but in the rice districts the grain is not usually consumed in large quantities.

(*c*) Several cases were found in which people had purchased lathyrus in a distant place and became paralysed after eating the grain for sometime (*e.g.*, cases in Nimar).

(*d*) Some men from hill areas, where the grain is not grown, came to areas where it was grown, received the grain as wages and suffered from paralysis.

(*e*) Some well diggers went to Nimar to dig a well : they received the grain as wages and were paralysed after eating it for about two months.

(*f*) The paralysis usually occurs in September or October and the grain is usually issued to labourers from the commencement of the rains in July.

(*g*) In Damoh the paralysis occurred earlier, but the grain had been issued earlier in the year.

(*h*) The class of persons affected affords the strongest evidence, for the well-to-do were not affected. It was chiefly the labourers who were paralysed. The Malguzars escaped and Government servants were not affected.

(*i*) The severity of the attack among the very poor, as the daily labourers, and especially among beggars, when contrasted with the mildness of the attack among the cultivators afforded valuable evidence.

(*j*) Valuable evidence was also afforded from the quantity eaten : those who ate the food mixed with other grain suffered less.

(*k*) The disease has prevailed in India at various times. Sleeman gave an account of it in Saugor in 1833 and attributed it to lathyrus. Irving wrote several papers on the subject in 1857 and following years tracing the disease to lathyrus.

(*l*) The European literature on the subject is extensive and translations of the most important of these papers have been received from which it appears that the cultivation of the grain was prohibited by the Grand Duke of Wurtemburg in 1671. The affection was traced to lathyrus in Modena (1681); in Tuscany, 1785; in Loir et Cher, 1829; in Abruzzi, 1847; in Naples, 1873; in Parma, 1881.

In 1881 there was a severe epidemic in Algeria and the subject was very fully investigated by French medical men.

(*m*) It is well known that horses become paralysed if they eat the grain for some time and several veterinaro-legal cases have been reported, *e.g.*, the Bristol Tramways Company case.

Various Theories.

The grain is frequently eaten, but it is only on rare occasions that it causes paralysis, and many theories had been advanced to account for its occasional occurrence. The common view among the people both in Irving's time and in the recent epidemic was that it was due to the ***hava*** (wind). Many other theories were advanced, but there are two main factors in the causation "Large Quantity" and "Long Time," and those who had advanced these theories did not give attention to these two points. There are many circumstances which opened the way for the multiplication of theories for—

(*a*) The grain is grown in different ways—on rice land and on wheat land—and Lathyrism is rare in the rice areas.

(*b*) The grain is cooked in different ways—as a dhal (when it is boiled) and as bread—where it is used as dhal, paralysis is not found.

(*c*) In some districts where the grain is largely grown paralysis is rare and in other districts, where the grain is grown in comparatively small quantities, paralysis is common.

(*d*) In some parts of the country the husks (testa) are removed and in other parts the husks are not removed, and it happens that the paralysis is rare in the parts where the husks are removed.

(*e*) There is great variation in the quantity that people eat: when used as a dhal only one-fourth of the whole ration is taken: when used for bread the meal is mixed with other meal in varying proportions.

(*f*) The grain is found in mixtures and the proportions of teora varies: the variation is increased by sifting, and a great variation is produced by famine.

(*g*) The disease usually occurs in the rains, hence some have considered the rains as ***a*** or *the* cause.

(*h*) The male sex chiefly are affected: hence some have attributed the disease to exposure.

(*i*) The people in the hill areas eat more "mahua" and they suffer very little from Lathyrism: hence mahua was supposed to act as a preventive.

Symptoms.

The cases might be divided into mild, moderate and severe. The preliminary symptoms are cramps and tingling in the legs. These are followed by paralysis which often comes rather suddenly. The symptoms in a moderate case are like those of spastic paraplegia. In a severe case the bladder and rectum are affected so the symptoms resemble those of the syphilitic spastic paraplegia described by Erb. There is loss of sexual power in the severe cases. (The lathyrus walk will be described and perhaps a case will be shown: the use of one stick and two sticks: the crawlers: reference to the scraping of the toes and the raising of the great toe in syphilitic spastic cases will be referred to).

Are there two varieties of the Grain?

The grain grown on the rice lands is smaller than that which is grown on the wheat land. In the rice areas the grain is used as a dhal and consequently a smaller quantity is eaten. The commonly held view that the small grain is non-poisonous is wrong as was proved by cases found in Mungeli.

Is the poison due to a Fungus?

Reasons for thinking that it is not.

Reference to the nature of the poison: to Professor Dunstan's investigations: to the investigations under the orders of the French Government: to experiments by Colonel Semple, R.A.M.C., at Kasauli: feeding experiments: recent cases at Gilgit investigated by Captain Macarrison.

Specimens of the various pulses used in India as food grains will be shown: the method of distinguishing lathyrus from the common gram (channa) which is largely used for feeding horses will be explained.

The grain is known by many names in India (as Lakh, Lakhori, teora, &c.) and by a large number of names in France.

PRELIMINARY REPORT ON AN OUTBREAK OF PIROPLASMOSIS

AFFECTING THE CALVES AT THE BELGAUM VACCINE DEPÔT AND ACCOMPANIED BY HIGH MORTALITY.

By Capt. F. H. G. HUTCHINSON, M.B. (Edin.), D.P.H., D.T.M. & S. (Camb.), I.M.S., and Capt. F. NORMAN WHITE, M.D. (Lond.), I.M.S.

Introduction.

The Belgaum Vaccine Depôt is temporarily situated on 9 acres of land within easy distance of Belgaum and Shahapur towns and not enclosed by any form of fence.

In normal times accommodation is found for 22 families and some 150 calves. In plague times refugees from Belgaum still further increase the congestion. Dotted here and there over the land in the neighbourhood are huts for other refugees, many of whom are now permanent residents.

Country roads form boundaries for the site on 2 sides, while these roads are connected by a third passing through the Depôt land. These roads are constantly being used by herds of cattle on the way to graze, and by bullock carts, large numbers of which daily carry material for the new Vaccine Depôt buildings. The Depôt calves have a grazing ground enclosed by wire fencing, but to reach it have to pass over the country road used by the town cattle. As will be shown hereafter, many calves, while in an advanced stage of the disease, must have used this road and probably mingled with town cattle.

A consideration of these points and of the plan attached will make it clear that effective isolation of the sick or newly purchased calves was quite impossible.

Source of Calves.

The calves are brought by contractors from wide areas, and vary in age up to 2½ years. No calf is ever received before weaning. In times of plenty owners are not willing to part with calves, and very generally refuse to do so unless the calves appear thin and likely to be unprofitable in the future.

History of the Epidemic.

The epidemic was first noticed on the 1st November, when 127 calves were present; 304 calves were subsequently admitted, making a total of 431.

There were 135 attacks with 86 deaths, giving a case mortality of 63·7 per cent., an attack incidence of 37·32 per cent., and a death-rate of 19·9 per cent.

The epidemic may be divided for purposes of description into 3 periods:—

(a) November 1st to November 26th—43 attacks with 35 deaths—the case mortality being 81·4 per cent.

(b) November 27th to December 22nd—22 attacks with 13 deaths—the case mortality being 59 per cent.

(c) December 23rd to January 20th—70 attacks with 38 deaths—the case mortality being 54·28 per cent.

The first period was notable for the measures taken.

(a) against rinderpest;

(b) for the destruction of ticks.

Inoculation against rinderpest was commenced on the 8th November, on which date 147 calves were in the Depôt. Of these—

8 were sick,
16 had been recently vaccinated,
16 exhibited a temperature above normal, and
107 were apparently healthy.

The apparently healthy were inoculated, and of them 21 were attacked with 18 deaths, the case mortality being 85·7 per cent. Of the 16 recently vaccinated calves only one was attacked. It is true that these calves were soon discharged from the Depôt, but 5 of the inoculated calves had died before the 1st batch left, while 3 of these vaccinated calves remained in the Depôt up to the 7th December and were discharged without any symptom of ill-health. Of the 8 sick, 5 died, the case mortality being 62·5 per cent. Of those exhibiting a temperature above normal, 9 developed other symptoms and 7 died, the case mortality being 77·7 per cent. It must be noted that the case mortality among the calves protected against Rinderpest was comparatively very high. No comparison of attack incidence is possible, as the recently vaccinated group was not exposed to infection for a sufficient period of time, while for reasons to be discussed later it is probable that all the 16 calves exhibiting a high temperature were infected.

During the 2nd period the case mortality was much reduced and some 174 calves were admitted to the Depôt.

This high admission rate was responsible for the exacerbation of the epidemic during the 3rd period, probably not owing to exposure of a larger number to infection, but because, as will be shewn hereafter, a large percentage of calves was infected prior to admission.

The measures taken for the destruction of ticks were—

(1) immersion of calves in a cattle dip;

(2) burning dry grass in stables.

It must be noted that complete tick destruction was impossible owing to the staff being unable to cope with the work involved by more than one immersion, and also to the failure to burn the grazing ground, the grass being too green. Tick destruction was commenced on the 17th November, and it is suggestive to note that the period of reduced mortality commenced about 9 days later. The institution of measures against the tick was suggested by the discovery of a parasite we now propose to describe.

Plates I and II illustrate accurately all the commoner forms and many of the rarer forms of parasite that have

been observed by us in the study of this outbreak of Piroplasmosis.

In every case some form or other of this parasite has been noted as occurring in the peripheral blood, and in every instance, when a *post-mortem* examination has been made, has the parasite been demonstrated in smears made from the various internal organs. These two facts alone would appear to us to warrant the assumption that the parasite about to be described is the actual cause of the disease with its attendant high mortality. We shall have occasion to refer to this point at greater length later.

As a reference to the plates will demonstrate, the parasite is characterized by a remarkable diversity of form. For purposes of description it will be convenient to divide the forms that have been depicted into the following groups :—

(*a*)	Bacillary Forms	... *e.g.*, Figs.	1, 2.
(*b*)	Oval Forms	... ,, ,,	6, 8, 9, 10.
(*c*)	Small ring forms	... ,, ,,	11, 12, 13.
(*d*)	Large circular forms...	,, ,,	30, 39.
(*e*)	Pyriform forms	... ,, ,,	51 to 58.
(*f*)	Irregular forms	... ,, ,,	59 to 77.

Both endocorpuscular and free forms of the parasite have been seen, but the latter are comparatively rare. The illustrations are from preparations stained, for the most part, with Leishman's stain ; a few were stained with Giemsa's stain. Many of the forms have been observed living in fresh preparations of the peripheral blood.

At the outset we were in considerable doubt as to the identity of the bacillary and oval forms of the parasite with the forms of groups (*c*), (*d*), (*e*) and (*f*). We now believe that they are all different forms of the same parasite. It will be convenient to detail here some of the facts that have suggested this conclusion.

Blood films were prepared from 116 apparently healthy calves on their admission to the Vaccine Depôt. Of this number 74 exhibited parasites in the peripheral blood. Four of this number showed large pyriform parasites in some numbers ; all these four calves were found to be suffering from fever (maximum 103—106); all became very sick, two died, one recovered, and one is still ill. The parasites that were found in the remaining seventy calves were of the bacillary or oval type ; they were rarely numerous, and ten minutes search in most cases only revealed the presence of two or three. Of these seventy calves forty-five (64 per cent.) subsequently became ill ; the remainder showed no obvious symptoms of illness ; their temperatures, however, were not taken.

Out of the forty-two calves who showed no parasites, only five subsequently became ill (12 per cent.). Excluding the possibility of subsequent infection, which we are of course unable to do with certainty, this result is well within the bounds of observation error.

Repeated observations have led us to the six following conclusions :—

(1) The presence of the bacillary or oval forms of the parasite in the blood of calves is not incompatible with apparent health.

(2) The presence of other forms is always associated with fever, and very often with serious and fatal illness.

(3) Calves which harbour bacillary or oval forms are (apart from fresh infection) very liable to subsequently exhibit the larger forms of parasite in their blood, in which case they become acutely ill.

(4) Bacillary forms of the parasite are not commonly seen in the acute stages of the disease.

(5) During and after convalescence parasites of groups (*c*), (*d*), (*e*) and (*f*) disappear from the peripheral blood, parasites of groups (*a*) and (*b*) reappear and may persist for some time.

(6) Every relapse or exacerbation of the disease is accompanied by the reappearance in the peripheral blood of parasites of groups (*c*), (*d*), (*e*), or (*f*).

Figs. Nos. 1—58 represent forms of the parasite that are frequently met with in the peripheral blood as well as in internal organs. The large " ring " forms, *e.g.*, Fig. 39, are rare in the peripheral blood. Blood taken from the very engorged liver *post-mortem* has occasionally been full of such forms. The irregular forms depicted in Figs. 58—77 are less common, but are met with in the circulating blood. The stages in the common method of division are depicted in Figs. 40—58.

Figs. 79—82 depict a less common method of division ; such forms have only been seen by us in blood from internal organs (liver and kidney). What the ultimate fate of the large round forms depicted in Figs. 82 and 83 is, is not clear. It would seem probable that each would divide again and give rise to two pyriform bodies. An analogous process is described in the canine piroplasma. Against this view is the fact that we have seldom seen four pyriform bodies in one corpuscle.

Appearances depicted in Figs. 14, 15, 16, 19 and 20 appear to be instances of double infection. We have not seen any indication of parasites as small as this undergoing division.

The large round and irregular forms exhibit very active amæboid movement.

Post-mortem blood from the liver is always very rich in parasites. Spleen smears exhibit comparatively few, smears from the kidney generally show numerous forms. Smears of the heart muscle are generally rich in parasites. It may be mentioned incidentally that sarcosporidia have been found in the heart muscle in every case in which this tissue has been examined microscopically.

Fig. 74 depicts a condition we have several times observed and is of suggestive significance.

In addition to the presence of parasites, blood films of diseased calves present one or two noteworthy characteristics—

(1) An enormous increase in blood platelets ;

(2) presence of megalocytes and microcytes ; irregularities in the shape of the red cells are not common.

Report on an Outbreak of Piroplasmosis.

Plates I & II.

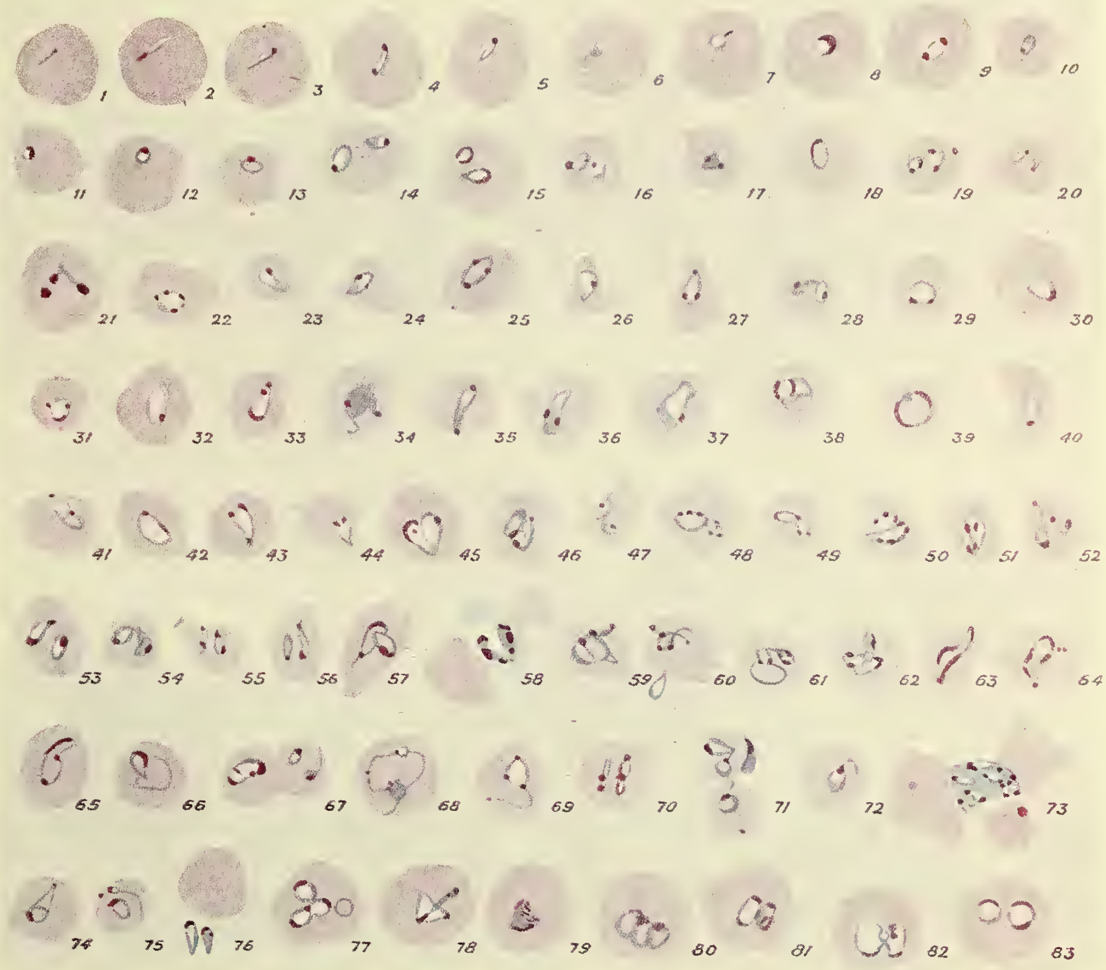


Plate III.

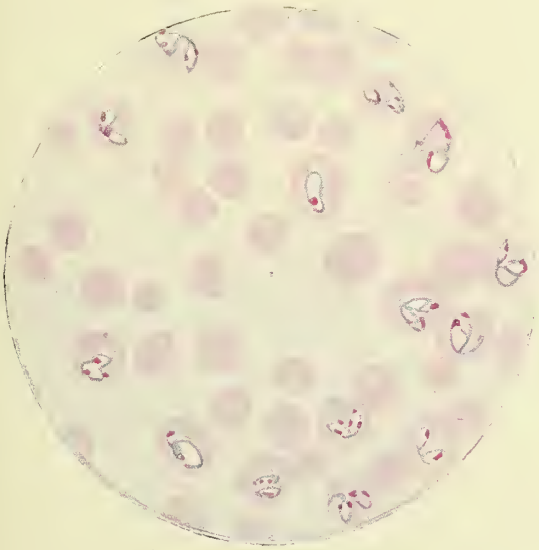


Fig. I.

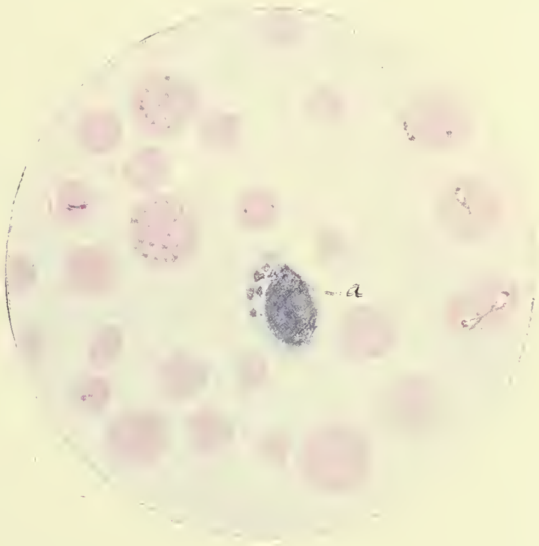


Fig. II.

Anæmia is a marked feature in the later stages of the disease and during convalescence. Counts as low as two and-a-quarter million red cells per c. cm. have been noted. Polychrome degeneration of red cells is not uncommon. A Leucocytosis has never been observed. We are not in a position to express any definite opinion as to the differential count of white cells, as, since these observations have started, we have not had opportunity of examining any undoubtedly healthy calves, whose blood would serve as a control. Granules staining like chromatin have frequently been noted in the protoplasm of large mononuclear white cells. (*Vide* Plate III, Fig. II *a*).

Plate III, Fig. I, is an accurate representation of one field of a film of peripheral blood taken from a calf during the acute stage of the disease.

Fig. II represents the blood of the same calf during convalescence.

Morbid Anatomy.

The main features found on 55 consecutive *post-mortem* examinations were :—

(1) Effusions into serous cavities.
(2) Gross changes in pleuræ and lungs.
(3) Petechiæ on mucous and serous surfaces.
(4) Congestion of viscera.
(5) Cerebro-spinal changes.
(6) Change in character of bile.

Effusions into Serous Cavities.

The pericardial sac was affected in 70 per cent., the pleural cavity in 60 per cent., while in only 2 cases was effusion noted in the peritoneal cavity. It is however possible that peritoneal effusion may, in a few instances, have been missed.

The fluid was generally straw-coloured, but was occasionally tinged a deep yellow. In 2 cases the fluid in the pericardium was blood stained.

Gross Changes in Pleuræ and Lungs.

(*a*) Pleuro-pericarditis in 50 per cent.
(*b*) Pulmonary infarcts in 80 per cent.
(*c*) Solidification in 48 per cent., a whole lobe or more was involved, the appearances suggested that solidification was secondary to infarction.
(*d*) Conversion of connective tissue in the anterior mediastinum into a gelatino-œdematous mass. In 2 cases the visceral pleura, and in one case the intrapulmonary connective tissues exhibited the same changes.

Petechiæ on Mucous and Serous Surfaces.

Petechiæ were commonly found on the pleura and pericardium and on the mucous membrane of various portions of the intestinal canal. The rectum was a favourite site and exhibited petechiæ in 29 per cent. Petechiæ had in 20 per cent. of the cases led to great congestion of the mucous membrane of the small intestine in lengths of about 2 feet. In rare cases petechiæ were found in the gall and urinary bladders, on the endocardium and surface of the brain and under the capsule of the spleen.

Congestion of Viscera.

The liver and kidneys were congested in practically every case ; in 50 per cent. the liver on section was stained a yellowish brown. The spleen was congested in 60 per cent. The mucous membrane of the 4th stomach shewed congestion in 35 per cent.

Cerebro-Spinal Changes.

Limited to congestion and increase in the cerebro-spinal fluid which was also turbid. These changes were noted in 73 per cent. of cases examined.

Bile.

Dark coloured and grumous in all but two cases. In one case the bile was inspissated and formed a cast of the gall bladder. Hœmoglobinurea was found in 17 per cent.

Ulcerations.

Small hæmorrhagic ulcers were found in the 4th stomach in 4 cases. Similar ulcers were found on two occasions in the urinary bladder. These ulcers were circular, with a hæmorrhagic ring and a punched out appearance.

In one case a chronic ulcer $1\frac{1}{2}'' \times \frac{3}{4}''$ was found near the pyloric orifice.

The blood was in all cases partly, and in many cases completely, unclotted.

Œdema under the jaw was noticed in one case.

Duration of Symptoms.

The morbid anatomy points to a disease of some duration, but in several cases calves died without giving previous evidence of ill health. For instance calves Nos. 493 and 615 died after an illness of 2—3 hours. Within a few hours of death they were apparently healthy, eating and walking out to graze. The *post-mortem* examinations revealed extensive consolidation of the lungs, and very large pericardial effusions. These calves had, 4—5 days previously, been inoculated against rinderpest, that is the temperature of each was normal on the morning of inoculation. Subsequent events would suggest that both calves were at the time ill, a point which might have been revealed had the evening temperature been taken.

The following table does not accurately represent the duration of the disease, but the period between the onset of the first noticeable symptom and death :—

Within 24 hours in 15 per cent. of cases.
„ 1 and 3 days in 17 per cent. of cases.
„ 3 and 6 „ in 41 „ „
After 6 days in 27 per cent. of cases.

Symptomatology.

The disease was revealed in 3 ways :—

(1) Onset of unmistakable symptoms.
(2) Use of thermometer.
(3) Examination of blood.

(1) Unmistakable Symptoms.

Diarrhœa was present in 78 per cent. of cases and in 54 per cent. was the first sign of the disease. In 10 per cent. diarrhœa and constipation alternated, the sequence being diarrhœa, constipation, diarrhœa. The motions

were invariably free from bad smell, liquid, and passed without apparent pain—in a few cases colic was noticeable. The motions sometimes contained blood, and in subacute cases, and especially in those in which diarrhœa recurred after a period of constipation, mucus was present. A few of these latter cases shewed tenesmus.

Anorexia was present in most cases, but generally only for a short period; in many cases the calves continued to eat and ruminate up to within a few hours of death. Cough was only noticed in 28 per cent., a surprisingly small number in view of the morbid anatomy. Most of the calves had either salivation, lachrymation or discharge of mucus from the nostrils.

Ulcers on the gums were extremely uncommon.

Hœmoglobinurea was found in 13 per cent. of the cases. Many cases were probably missed as the symptom was very transient, and, as no attempt could be made to collect urine, cases without a highly coloured urine would be likely to escape notice.

Albumenurea was never found apart from hœmoglobinurea.

Emaciation.—Always marked and usually rapid.

Cerebral symptoms.—A comatose condition frequently ushered in death, with, in a few cases, distinct movements of the hind legs. In a few cases the onset of coma was the first indication of disease; in one such case the calf recovered temporarily. Paresis was not noted: the progressive muscular weakness could well be accounted for by emaciation. No tender spots were found over the spine or loins.

(2) Temperature.

In some cases the presence of disease was revealed by the use of the thermometer and in others by blood examination. The charts attached shew well the characteristic intermittent temperature of quotidian type. In all these cases a raised temperature was the only evident sign, if emaciation be excluded.

The temperatures of these calves were taken for two reasons: in the first 8 owing to the blood films revealing unmistakable parasites, and in the last 7 owing to the practice of taking the temperatures of all calves selected for vaccination for one week previous to vaccination.

The temperature charts of the calves exhibiting other marked symptoms were of the same general character. These 15 temperature charts are of great interest, but for the use of the thermometer these calves would have gone out to graze with no apparent symptom of ill-health, for emaciation is not uncommon among Indian cattle. They suggest an explanation for the variation noticed between the duration of symptoms and the conditions revealed on *post-mortem* examination, and also for the fact that a certain percentage of the calves in whose blood parasites were found on admission did not at the time nor subsequently exhibit noticeable symptoms of disease.

Relapses were fairly common, and occurred in some 20 per cent. of the cases. It is probable that many of the apparent initial attacks were really relapses from previous infection. The actual cause of the relapse would seem to be an irritant, such as cold, fatigue or vaccination. It is noteworthy that 37 per cent. of the calves whose blood exhibited parasites on admission, and who were subsequently vaccinated developed marked symptoms during the incubation period of vaccinia. Not one of the calves whose blood was free from parasites developed disease during this period.

Relation of Disease to Vaccination.

Of 74 calves vaccinated in succession, 42 shewed no parasites in the blood; of these, 88 per cent. were used for preparing vaccine, 7 per cent. were completely unsuccessful and in 5 per cent. the vesicles were dried.

In 32, parasites were found in the blood at the time of admission; 53 per cent. were used for preparing vaccine and 25 per cent. were completely unsuccessful, while in 22 per cent. the vesicles were dried.

The case of calf No. 752 is interesting; it was vaccinated on 12th December, after 96 hours it was taken ill, and there was no evidence of vesiculation. The calf was extremely ill, and the blood shewed an enormous infection. On the 22nd the calf was much better, and on the 24th, that is 288 hours after vaccination, the vaccine vesicles were found developed.

Differential Diagnosis.

This fatal epidemic having been associated with diarrhœa, exclusion of rinderpest as a diagnosis demands consideration.

Against rinderpest are the following points:—

(1) Inoffensive stools.
(2) Intermittent temperature.
(3) General absence of ulcerative changes in the alimentary canal.

BERI-BERI, ITS CAUSE, SYMPTOMS, DIAGNOSIS, TREATMENT, PATHOLOGY AND PREVENTION.

By W. LEONARD BRADDON, M.B., B.S. (Lond.), F.R.C.S. (Eng.).

Definition.

Beri-beri is a disorder of the nervous system, in which, owing to a peculiar scattered degeneration of neurones in the sympathetic and spinal levels, motor, vaso-motor and sensory functions are impaired or destroyed, the evolution of symptoms proceeding in an ascending order, reaching rarely the cranial nerves, and never the cerebellar and cerebral cortex.

Cause.

The cause of beri-beri is an *intoxication*, which may be of every grade of destructiveness, from the imperceptible to the severest, the result of a peculiar and probably specific poison, contained so far as is at present known only in rice, or the products of its digestion, when consumed in a certain state, namely, when it has been exposed for some time subsequent to decortication, so as to become stale.

The evidence of this origin of beri-beri, first fully proved by the writer, includes such facts as the following :—

(*i*) In the Malay Peninsula, where beri-beri is so common as to have been called endemic, rice-eaters and non-rice-eaters live side by side and are exposed equally to all external conditions productive of disease. But beri-beri attacks only the rice-eaters : never those who eat no rice.

In the last three decades, there have been treated in the local hospitals, among the rice-eaters, *over a quarter of a million cases of beri-beri*, in a population not averaging twice that number. One-fifth of all hospital admissions was for beri-beri. During the same term there have been treated for other disorders, from a much smaller population, as many non-rice-eaters. *Not one of these had beri-beri!*

(*ii*) In the same region again, there dwell side by side 300,000 of a race (Chinese) who eat almost exclusively rice of one particular sort, and as many persons of different races (Malays, Tamils and others) who consume equally exclusively rice or rices of other kinds.

Now, of the quarter million of cases of beri-beri mentioned, almost the whole, or to be exact $97\frac{1}{2}$ per cent. have been furnished by the eaters of the first sort of rice, the Chinese ; all the other classes of natives, the Tamils, Malays, Javanese, Sinhalese, &c., although equal in number to the Chinese, furnished but $1\frac{1}{2}$ per cent. of the cases. The Tamils and Malays are in fact absolutely immune from beri-beri so long as they adhere only to the sorts of rice to which they are generally accustomed. But it happens that there is a margin of individuals who for one reason or another have recourse to the same sort of rice as is consumed by Chinese. Such individuals do not comprise 10 per cent. of the whole. But it is among this small proportion of them that all their cases of beri-beri—the $1\frac{1}{2}$ per cent. not provided by the Chinese—occur.

The rice used by Chinese may be of any derivation—it is the ordinary white rice of commerce, imported from Siam, Saigon, Burmah, Java, or of local production, decorticated in mills on a large scale, by a process which scours away, together with the husk, all the surface layer of the seed. Coming into consumption at an uncertain date, but nearly always a long while after milling, the various samples of rice used by the Chinese agree only in this : that they are wholly decorticated and always *stale*.

Malays use rice grown by themselves, which is eaten almost freshly as decorticated, as a little of it is for use by the household, day by day. Being not heavily milled, but only lightly pounded by hand, it often retains much of the inner envelope, and the surface layer of seed-cells, which contain a large part of the total proteids and fat of the seed. Such rice may be termed for convenience " Fresh Rice."

Tamils in this region are fed almost exclusively on rice prepared from the raw grain by a special process. It is soaked for one or more days in water, often till the grain begins to germinate ; next it is rapidly steamed so that the husks burst ; last it is dried—seldom completely—and the husk, which is now easily separated, is removed by light milling.

The result is a yellowish, semi-translucent, toughened, and perhaps partly malted grain, on which the whole of the inner envelope (the perisperm) and the surface layer of seed-cells are preserved intact. The writer has given to rice so made the epithet of " cured."

In spite of the enormous number of cases of beri-beri treated in the British Malayan Hospitals—some five or six thousands every year—an unequivocal case has never been recorded in an eater of either fresh, or pure, or of any but stale uncured rice.

That the disease is determined, therefore, by something in the rice consumed, would appear to be a proposition, for the proof of which there can be no further need of witnesses.

Nevertheless the conclusion afforded by this experience—itself a vast though undesigned experiment carried on over an area, and for a time, and with numbers sufficient to eliminate all possible fallacies of proportion—has been put to the proof again by tests upon a smaller scale with safeguards of sufficient and careful controls.

Thus Dr. Wm. Fletcher, setting out with the intention (as he frankly stated) of entirely disproving the author's view of beri-beri causation, the evidence for which he clearly did not appreciate, carried out the following observation at the Lunatic Asylum at Kuala Lumpor in Selangor.

One-half the inmates (daily average population 60 to 80) were put on cured, the other half on uncured, rice for their staple diet, there being no other difference made in the food or any other circumstance (except that the different parties slept most of the time in different wards), while all known or suspected beri-beries were first weeded out and sent to hospital elsewhere. The experiment began on the 5th December 1905 and continued till the end of June 1908. The result was that throughout the term beri-beri attacked only the party on uncured, never any of those on cured rice. This held good in whichever of the wards (there were two) the respective parties were housed, and even when by design they were allowed to sleep in the same room together. With a view to throwing light on a possible " place-factor " (*e.g.*, bed-bugs) the parties occupied each other's sleeping quarters alternately for six months at a time. The whole period of the experimental observation comprised five such terms, during which each of the two parties was exposed equally to all the supposable factors causing beri-beri, except as regards the difference in their rice. In other

words there were ten exposures or experiments. In five of these a single known difference was made; and it was in these five that beri-beri occurred; in the five exposures where there was not this particular condition there was no beri-beri. The factor with the presence of which beri-beri uniformly coincided, was the use by the party attacked of uncured rice for food. Those on cured rice never got it, although living in a place and at a time when it was rampant among their fellows on the other sort.

In this Asylum beri-beri had been prevalent every year since 1898. There had been in 1905, in an average population of 66 inmates, fed on Siam rice (uncured stale), 88 cases of beri-beri, with many deaths. In 1906, half the population, 32, on the same rice, gave 38 cases; the other half, on cured rice, none. In 1907, half the population, 40 persons, gave, on uncured rice, 31 cases. The other half, on cured rice, none. In 1908 (first half year only) 43, on uncured rice, gave 8 cases, the others, on cured rice, none. From June 1908 to December 31st in the same year the whole population had cured rice, and there have been no more cases.

Another demonstration of the cause of beri-beri was afforded by experiences gained at Durian Tipus, in 1907-08, the result of an opportunity granted to the writer by the local Government to prove by an independent and scientifically controlled experiment the truth of the views he had already laid before them and which, in spite of the evidence, their official advisers had not merely not supported, but had largely opposed. In this case some 300 Javanese labourers employed at road making by a private contractor afforded the material for observation. The conclusions which are to be published in detail elsewhere by Drs. H. Fraser and A. T. Stanton, of the Kuala Lumpor Institute of Medical Research, who officially conducted the observations, were almost more striking than those gained by Fletcher. I may be perhaps permitted briefly to summarise the actual results obtained.

The coolies had been, during the first part of 1906, fed on uncured rice. Many of them at that period were attacked by beri-beri. On the writer's advice they had then (for the six months immediately preceding the experiment) only cured rice, and throughout this term had been entirely free from beri-beri. At the beginning of the observation they were independently examined by Dr. Fletcher and Dr. Fraser and were found to be without any sign of the disease.

The coolies were then divided into two divisions of about equal number. One of these divisions was placed for the next six months on uncured rice; the other division retained their cured rice. At the end of five months the first division had ten per cent. of their number invalided with severe beri-beri, and many more with milder symptoms. The cured rice division remained free of all signs of the disease.

The conditions were then reversed. For the next six months the affected party were put on cured rice, and the others on uncured. Beri-beri immediately ceased among the first division, and from that date no more cases developed among them. But among the second division now on uncured rice the disease appeared, about ten per cent. of their number becoming attacked severely, as happened with the first party, and after about the same length of time; and again, when their uncured rice was replaced by the cured, this second epidemic also at once abruptly ended.

The two divisions were broken up into smaller parties, housed under exactly similar conditions at different stations. Care was taken that unintended infection should not be conveyed from one party to another, or to either from without. In all there were seven different camps or stations occupied by the coolies, but during the term of experiment only six. Each station was occupied in turn by a party on cured, and a party on uncured, rice. With one exception the party in occupation on uncured rice had been on that rice for a period of five months at that station, or at the time when they moved into occupation of the station. Now without taking into account the year preceding the actual period of experiment (a year) gave the following remarkable results. At five out of the six stations when the party in occupation were on uncured rice they were attacked by beri-beri. At these five stations the party when attacked had been on that diet for a term of five months. At the exceptional station where the uncured rice-eaters escaped beri-beri, they had not been on the diet for more than four months. At no single station, however, did any member of any party get beri-beri when subsisting on cured rice.

Taking into account also the year preceding the experiment proper, there were seven stations occupied, each for two successive terms of about six months, by a party on one sort of rice or the other in turn—*i.e.*, to put it numerically, there were fourteen events, or exposures of groups of susceptible subjects to all the causes of beri-beri, made as nearly as possible under conditions exactly alike for all, except for a single experimental difference. This experimental difference was made in one half, or seven of the events. Of the seven in which it was made beri-beri occurred in six. Of these, an equal number, in which the difference was not made, beri-beri occurred in *none*.

It is worthy of note in these results, both that beri-beri attacked uncured rice-eaters in houses where cured rice-eaters had lived for a long while quite free from it; and that it failed to attack cured rice-eaters in places where it had been prevalent among their fellows eating the other sort; even when both gangs were by design made to live in one house together the attacks remained confined entirely to the eaters of *uncured* rice.

Attempts to isolate from stale rice its toxic principle have so far failed. It cannot be told therefore whether the disease, its effect, is the result of a dilute poison more or less generally spread throughout all the grains consumed, or something occurring in fewer grains, in intenser form. But there is considerable evidence to show that the severity of the effect varies directly:—

(*a*) With the *quantity* consumed;

(*b*) With the length of *time* for which it is consumed;

(*c*) With the age, *i.e.*, the *staleness* of the rice when used.

The effect varies indirectly:—

(*a*) With the *resistance* of the individual; the very young and old often escape.

(*b*) With *use*—acquire toleration; those who begin on rice only a little stale later resist that which is very stale toxic much better than those who begin straightway on the latter.

(*c*) The *dilution* of the rice, especially with fatty and proteid food.

Evolution.

There is no fixed term, whether of incubation, invasion, progress or recovery, in beri-beri. Depending primarily on the dose of poison taken, and the frequency of its repetition, symptoms are produced which may be merely transitory or slight and persistent, which may cause severe illness for weeks or months, or, in the worst forms, prove fatal within a few hours.

Recovery may begin, as death may intervene, at any moment. Permanent lesions may be left, in weakened hearts with dilated orifices, in enfeebled musculature, in contractures of joints disabled.

The clinical forms of beri-beri are infinitely graded and numerous. They depend in each individual on the part of the neuro-muscular or visceral systems which is most attacked; and the extent to which each or all of these several systems, the locomotor, sensory, cardiac, vasomotor, pulmonary or digestive, suffers. Broad lines of difference between large groups of cases are recognised in such terms as "dry or atrophic," "wet or dropsical," "rudimentary," "larval," "abortive," "acute," "sub-acute," "residual," "acute-pernicious" beri-beri and "*fulgurante*," "*foudroyante*" and "*schlagartig*"—applied to its rapidest fatal forms. But such distinctions are all arbitrary.

Symptoms.

Best studied in cases of slow evolution and moderate severity, these are best analysed under the heads of the different functions severally affected.

Sensory System.—The earliest change is diminution of common sensation. Perception is first retarded. Then there is failure of perception of light touches as with cotton wool or a feather. The tactile areas become enlarged, so that impressions as far apart as the foot and the thigh cannot be separated when made simultaneously. These changes are evident sooner in the lower than the upper extremities or trunk. In the lower limbs they are manifest first, as a rule, in the skin areas supplied from the lowest spinal segments. Thus they appear first in the centre of the upper calf, and thigh (S. ii) next on the foot, the dorsal aspect of toes, the sole, heel, and sides of calf (S. i), the dorsum of foot, and outer aspect of leg (L-5), the inner side of leg, and front of knee (L-4), front and sides of thigh (L-3), and so on upwards until the whole sensory area is involved. Hyperæsthesia to this degree exists in many eaters of rice who have no other subjective symptoms and are supposed entirely healthy. The process continuing, hyperæsthesia, and various paræsthesia develop, and go on to anæsthesia which may be general and complete. The paræsthesia include sensations of pricking pins-and-needles, numbness, aching, smarting, burning, and may, though commonly not acute, reach any degree of severity. In some cases both skin, bones and joints are excessively tender if pinched or tapped. The changes seldom appear to be, and probaby never are exactly limited to single areas, certainly never to the anatomical distribution of nerve-trunks. The lower segments suffer first and chiefly, but all areas may become involved in such rapid succession that the distinctive ascending character is not perceived. A common condition is that known as sock and glove anæsthesia, where the area of its distribution is indicated by the term. In the face anæsthesia seldom occurs in mild cases, but it is described as common round the mouth, in Japan, and it is often present in the pharynx. Another common symptom is acrodynia. The *nerve-trunks* in most cases of a few weeks' standing become tender to pressure, and they are sometimes distinctly thickened. Light pressure just internal to the anterior superior Iliac spine, or below the head of the fibula, or in the popliteal space, will reveal the condition of hyperæsthesia in the nerves at those points. This is often so great that the slightest pressure is extremely painful. The writer regards this as one of the most useful diagnostic signs of beri-beri.

The muscles are always tender on pressure, especially the calves and front of thigh. But whether this is sensitiveness of muscle itself, or of the nerve-trunks running through the muscles, it is not easy to say.

Reflexes.

The cutaneous reflexes exhibit no special changes. They may be in early stages exaggerated but this is not constant. The Achilles, the quadriceps and other tendon jerks are in nearly all cases during a brief initial phase of acute attacks exaggerated, becoming next weakened, and finally in almost all cases completely lost. The knee jerk does not reappear, even when cases have apparently otherwise quite recovered, for a long period, often not at all.

Motor System.

Cramps, fatigue, heaviness, weakness, gradually merging into definite inability to move the muscles (paralysis) are the subjective signs usually complained of in order of their appearance. These disturbances are first referred almost invariably to the legs, first the muscles in front, next the calves and thighs. Defect in finger movements and strength of grip are next noticed, because probably deficiencies in trunk-movements are less easily appreciated. Objectively the foot-muscles, peronei, anterior tibial muscles, gastrocnemii, quadriceps, are easily made out to be affected most in that order. There follows on in severe cases complete ascending flaccid paralysis, which involves the muscles of expression, phonation, deglutition, and rarely the ocular group. The evidence of affection of these is more rare, because probably the victim has succumbed before their destruction.

Increased irritability precedes the weakening of the muscles probably in all cases. The hypermyotonus is shown by increased reaction to mechanical stimulus, the fibres heaping up in large wheels under a light blow, and in increased response to galvanic current. Later, there is diminution of both galvanic and faradic excitability, in that order, and finally a reaction of degeneration. In the early phases affected muscles are often swollen, sometimes greatly so. Later in all cases where there has been definite paresis, there is *atrophy.* This atrophy varies exactly with the area and degree of paralysis and may be rapidly recovered from, or leave the patient with insufficient muscle-elements to move a single bone.

Although the paresis, or in severer cases the paralysis may be general, it is always most evident in the extensors, whether of leg or hand. Hence toe-drop, wrist-drop are characteristics of beri-beri. While the early paralysis of glutei and the other muscles upon which the erect posture depends makes its maintenance an impossibility. The patient, even when able to move to some extent both toes, legs and thighs, is nevertheless wholly unable to stand, and when support is withheld collapses at the joints like an articulated skeleton.

As the disease advances the abdominal walls, intercostals and diaphragm successively weaken. But often paralysis of the diaphragm is apparent before failure of intercostals is perceptible.

The paralysis is, except possibly in the very worst cases, never of any single muscle in the mass, or of any group supplied by a given nerve or nerves in their totality. Rather it is of scattered elements, selected apparently capriciously in every bundle, but with a preponderance of effect on those of the lower levels.

There is often paresis of bladder, but the sphincter is never involved.

Vaso-motor Symptoms.

To disturbance of the vaso-motor mechanism is ascribed *œdema* which appears with the very rarest exceptions to some degree in every case. As with the sensory and motor signs, the first seat of appearance of this is in the levels supplied from the lowest spinal segments. Thus it is seen first in many cases in the genitals; oftener on the surface of the shin in its lower third. A certain indefinite infiltration of the tissues not definitely demonstrable as œdema seems in all cases to precede the appearance of true effusion. In the face this produces a "pasty" or "puffy" expression, which forms one of the earliest signs attracting attention. When definite swelling or dropsy appears first or early in the face, it is held to be of grave omen, presaging a very severe attack. Effusion takes place in the muscles and in the serous cavities equally with the subcutaneous tissues, and may produce extensive ascites, and more rarely serious hydropericardium. A moderate amount of pretibial œdema is often to be detected in persons eating rice who show no other sign of disease except perhaps alteration of tactile sensation.

Attacking the lungs and sometimes the glottis, characteristic crises of dyspnœa are produced by œdema in severe cases often with fatal results.

Among other signs ascribable to a vaso-motor origin are, in all likelihood, an almost constant dry coldness and pallor of the skin, and sometimes of the mucous surfaces. Constriction of peripheral arteries, so that the pulse may be extremely small, while the heart appears to be beating forcibly ("unconformability" of pulse and heart-beat); certain asthma-like pulmonary attacks; and diminution of renal function.

Cardiac Symptoms.

Increased irritability of heart muscle is shown in early stages of beri-beri by an abnormal acceleration or frequency of its beat on slight exertion. There is then shortening of the diastolic pause, and a "tic-tac" fœtal sound is produced. But at rest prolongation of the first and accentuation of the second sound. Later, there is weakening of the walls, especially evident on the right side; all the orifices may become relaxed, and the tricuspid especially so. There are then marked bruits at most of the orifices of which the most loud as well as constant is a pulmonary systolic murmur (reflux into the appendix), and a double second sound. Often there is obvious reflux into the veins of the neck, and epigastric pulsation. Displacement of the apex outwards, increased dulness to the right and diffused impulse mark the progress of dilatation. In severe cases the beat is continuously increased in frequency and irregular in rhythm till exhaustion ends in syncope. Temporary attacks of cardiac disturbance, resembling very much those due to alcohol, are a common feature of mild, or what may even be called "larval," beri-beri.

Pulmonary Symptoms.

Attacks of dyspnœa occur in mild form in the earlier, and in severer degree in the later, stages of beri-beri.

Milder attacks take the form of asthmatic seizures, with the usual signs. Thus there is short and unhampered inspiration, prolonged and difficult expiration. The lungs are distended with air, and auscultation reveals, with perhaps some rhonchi and coarse rales, noisy stridor and creaking and whistling sounds.

The heart during such attacks may be accelerated, but otherwise beating well and regularly. This condition may pass off in a few hours or continue with exacerbations, or intervals of relief, for days together.

A more serious condition is embarrassment due to œdema. This, which is in part specific, and in part the result of deficient cardiac pressure, leading to stasis, is evidenced by diminution of resonance, and of vesicular murmur, by fine and coarse rales on both respiratory phases, and by the pouring out of effusion which appears as frothy watery, often profuse, expectoration, sometimes tinged with blood.

It is in such crises, partly of cardiac and partly pulmonary embarrassment, that most of those acute cases of beri-beri die which survive the earlier days when implication of the heart alone oftenest entails a fatal issue.

Digestive System.

Loss of appetite, constipation are usual early symptoms. But there may be diarrhœa, and in severe cases vomiting which is a sign of bad omen. A feeling of sickness, fullness at the pit of the stomach, or severe gnawing pain there, burning, and tenderness on pressure, a "girdle pain" as of constriction round the middle are all observed signs in severe cases. Congestion of the pharynx has been noted, as also swelling of the parotid and submaxillary glands.

The *Renal* functions are in most cases diminished, the quantity of urine and its specific gravity being lowered and in very bad cases suppressed. Reflow of urine coincides always with the disappearance of œdema and beginning of recovery. Beri-beri does not produce albuminuria.

Negative signs.—In beri-beri there are never mental complications, there is at no time any real ataxia, in the sense of movement of muscles not intended to be called into action. Choreiform or spastic movements, convulsions, coma, do not occur. There is no initial fever—rarely anything more than trifling elevation of temperature. There are no exanthems, nor any "trophic" or generative skin-lesions. There are no inflammatory troubles. There is no alteration of the blood. There is neither anæmia, nor leucocytosis, nor eosinophilia, nor as far as is known any specific alteration of leucocyte count.

Diagnosis.

The diagnosis of beri-beri can easily be made, and its distinction from most of the maladies which have been mistaken for it made certain by the recollection that it is in essence a *peripheral neuritis,* of which the pathognomic signs, equally with those of any other peripheral neuritis must include impairment of sensation, impairment of motility, and definite muscular atrophy.

In *Epidemic œdema* there is, according to the accounts of Macleod, Abecrombie, Anderson, Daley, Campbell, Rutherord, Delaney, and others, not only definite fever, and often exanthem at onset, but there is never any true paralysis, anæsthesia, atrophy of muscles, tenderness of nerve-trunks, nor any other definite sign of peripheral or central nerve-implication.

Pelagic Dropsy is the so-called "beri-beri of sailing-ships" occurring in non-rice-eating crews on badly fed ships during long voyages. There is not, according to the Report of the Norwegian Commission and later of Holst who especially investigated both this disorder and true beri-beri in pelagic dropsy, any constant or definite implication of the nervous system, any more than there is in epidemic œdema, which it indeed more closely resembles. No true paralysis, no tenderness of nerves, no muscular atrophy, has ever been noted in either complaint. In no epidemic of pelagic dropsy, or *any* epidemic among non-rice-eating communities on ships, has the production of cases of amyotrophic paralysis, *without any dropsy*, the so-called "dry" beri-beri, ever been recorded. But such cases are a *constant feature* in every epidemic of true beri-beri.

In *Ankylostomiasis* when this is severe enough to entail as it often does general anasarca, and great consequent weakness and wasting, the special distinction occurs in profound anæmia, with great eosinophilia, neither of which symptoms is to be seen in beri-beri. Here again there is absent true paralysis; even where there is weakness sufficient to be miscalled paresis, or wasting to be called atrophy, it is not especially marked, as in true beri-beri, in the extensor groups; there is never any real anæsthesia, very little tenderness of muscles, and none whatever of the nerve-trunks.

From *peripheral neuritis of alcohol and arsenic*, beri-beri may be distinguished by the presence in either of the former of their other characteristic stigmata. In alcohol the tremors, hesitance and deficient memory; in arsenic the pigmentation, coryza, hoarseness, and skin changes, as keratosis desquamation, erythema, etc., etc., should enable a diagnosis to be made, even where no history of the habit is forthcoming. Moreover, it is stated that in both alcoholic and arsenical poisoning the *left* side of the heart becomes dilated, whereas it is the *right* in beri-beri.

From other forms of *peripheral neuritis*, such as are sequel to puerperal fever, influenza and other maladies, it seems to the writer that beri-beri would be distinguishable by the peculiar selection in the latter of the extensor groups of muscles for its chief incidence, and the right sided dilatation of the heart which seems to be specific.

In any case since rice is the cause of beri-beri, it is worth while insisting that no case of disease resembling it however closely should be called beri-beri, affecting a patient who is not a consumer of stale rice.

Pathology—Coarse Anatomy.

In the minor cases of beri-beri, examined when cut off by intercurrent affections, the naked-eye appearances may be *nil*.

In cases of moderate severity and some standing, there is to be seen always enlargement with dilatation of the heart, especially of the right side, softening of its walls, as of the muscles generally, congestion (moderate) of liver and perhaps spleen, rarely of kidneys, congestion and emphysema of lung, and in almost every tissue œdema. The serous cavities all have some effusion, which in the pericardium amounts usually to three or four ounces of clear yellowish fluid. Muscles, spinal cord and brain may all alike be softened by œdema. In addition the muscles generally may show some yellowness, due to fatty softening.

In acute cases, the pernicious type, the appearances are those which are seen in other acute intoxications. In addition to serous effusion everywhere, the serous surfaces show petechial spots and extravasations; the whole intestinal tract may show congested spots and patches. Hæmorrhagic erosions especially occur on the valvulæ conniventes of stomach and still more in the duodenum. There may be congestion of brain and spinal cord, effusion in the ventricles and central canal, and even hæmorrhagic foci. The nerve-trunks at such a stage show nothing special. The lungs may show acute œdema and static

congestion. The right ventricle is distended with dark blood, and a thrombus partly ante-mortem may extend from it into the appendix, and the pulmonary vessels. The left side is usually empty.

Microscopic Anatomy.

According to Yamagiwa and H. Wright, whose researches would appear to be the most complete, the essential and constant change in beri-beri is a change going on to destruction of the *terminations* of the nerves, throughout the system.

Yamagiwa describes the first change as an effusion or formation of a vitreous homogenous material within the sheath of Schwann, by which the axis-cylinder is compressed and destroyed, undergoing in the end a change into the same sort of substance, which he regards as altered myelin. Ultimately the cylinders entirely disappear.

H. Wright finds the first changes also to be in the termination of the neurones, the myelin of which becomes altered, breaking up into oily drops, and finally disappearing when the axis cylinders become fragmented and disappear. Secondary to this terminal change, and as he believes, their direct effect, are alterations ("axonal reaction") in their trophic cells. The protoplasm becomes cloudy, rarefied and vacuolated, the Nissl's bodies disappear, the nuclei and nucleoli are displaced and finally extruded.

Wright found changes of the kind affecting variable numbers of cells *in every ganglion*, whether spinal or sympathetic, examined; in the intrinsic cardiac ganglia, and in the plexuses of the intestine. He concludes accordingly that the poison causing their destruction is diffused generally throughout the system, but has special selective effect on particular cells.

Neither Yamagiwa nor Wright mentions the condition of the end-plates in the muscles, or any other of the final nerve-endings, upon which, if the beri-beri effect be truly peripheral, it seems reasonable to suppose the poison must first act.

Wright declares the changes in the neurones to be exactly comparable to those produced by such intoxications as alcohol and chloroform. In his opinion many of the cells presented a condition of partial poisoning, from which complete recovery would be possible, others indicating actual process of repair. Only in late stages was there degeneration of the nerves of a Wallerian type; in some cases there was ascending degeneration in the posterior columns consecutive to atrophy of sensory fibres. There is according to both these observers no inflammatory reaction of any kind in any part of the nerve-trunks. There is in beri-beri in fact properly speaking no "neuritis" in the sense of interstitial change. The affection is a direct parencymatous degeneration of the nerve-elements, practically a chemical reaction—a specific intoxication—pure and simple. Following on the nerve-change the dependent muscle fibres undergo degeneration cloudy, fatty, fibrous, and ultimately disappear.

The peculiar fact that the beri-beri poison acts not on whole groups or regions of nerve cells at once *en masse*, but only on separate cell units discretely scattered throughout the whole system, affords at once a simple key to the complexity of the clinical manifestation, and a very strong support—were any support needed—to the view of the intimate cause of the disease, as due to an extremely subtle and powerful poison consumed in rice.

For it may be supposed that under ordinary circumstances only a small dose of the poison is ingested at one time. The poison is such that it is fixed, like tetanotoxin, only by certain nerve-cells, and among these only by such as are in a particular stage of nutrition or perhaps of growth.

If the dose be one from which the cells can recover, or if the cells poisoned be only few, their incapacity will not entail obvious derangement of movements in which very large numbers of cells are concerned, *e.g.*, the loss of locomotion. When, however, through repetition of the poisonous dose, the numbers of cells destroyed increases, a point is reached when the proportion of muscle fibres left effective in the muscle mass is too small to meet the strains required. Then there is paresis, or in severer grades paralysis. In the case of the heart, not only is there weakening of the direct motor power, but there are changes in the accelerator ganglia, and, in the vagus, such as interfere with its regulation and control. The heart accordingly is the first organ to exhibit definite signs of beri-beri, and in many cases is so sensitive to the poison, that the patient dies of syncope before any other symptom is noted or suspected. Such unexpected deaths often appear as the heralds of an epidemic.

Prognosis.

It could formerly never be said how a case of beri-beri would eventuate. The cause—the stale rice—being still plied upon the victim, even in the hospitals, many cases were naturally made much worse. Even those who by natural reaction had established a temporary toleration and recovery were subject, owing to repetition of the poisoning, to relapse.

Even now it cannot be foretold how a case left entirely untreated may eventuate, or what the issue may be, even if properly treated, for the first twenty-four hours.

Should any moderate case of beri-beri survive that period, it should, in the writer's view, never prove fatal. The very severe cases admitted almost moribund, with irreparably dilated hearts, pulmonary congestion and œdema, and often thrombosis, are generally beyond relief. But it is astonishing to observe what recoveries are made under certain treatment in apparently the most hopeless of such cases.

Treatment.

There is no specific cure for beri-beri, the treatment is entirely symptomatic. There are, however, certain necessary measures to be taken.

Since the disease is the result of a poison in stale rice, this should be withdrawn at once from the dietary. The writer finds rice of any kind prejudicial to the beri-beri. Fresh meat and vegetables and fat should be liberally given, in condition suitable for assimilation.

There being presumably poison in the intestine not absorbed possibly when the case is first recognised, attempt should be made by purgatives to eliminate it. For ordinary cases Castor oil in full dose suffices. Presumably there remains poison also in circulation not yet fixed by any cells so long as the disease is advancing. The aim should be by antidotal remedies and emunctory processes to neutralise the effects of this.

As I have said there is no real "specific" for beri-beri. But there is a drug which very nearly deserves that title. This is *atropine.* As the alkaloid, or in Tinct.-Belladonnæ it should be given immediately in full doses to every case of beri-beri.

The action of atropine is to neutralise, if not all, definitely some of the effects of the beri-beri toxin, the muscarin-like character of the reactions of which (as exhibited in pallor, constriction of pulmonary vessels, muscular poisoning) first suggested to the writer atropine as an antidote. Cases where the dilated heart is finally bitten, or where there is already pulmonary thrombosis, cannot naturally be relieved by any means. But the spectacle of certain cases apparently moribund with dyspnœa due to combined cardiac failure, and pulmonary embarrassment, which revived almost magically, and are saved from death by the administration of 1/100dth or 1/50th of a grain of atropine hypodermically given, has convinced the writer that this is a remedy which should be used in every case.

It would seem that those cardiac muscle fibres which are not wholly destroyed may be assisted in their work by drugs, which directly stimulate their output, and for this purpose caffein and squill may be used. Digitalis is, in the writer's experience, distinctly dangerous in any dose, and ought not to be used in beri-beri.

The reconstruction of damaged neurones is probably not aided by any drug, and the stimulation of impaired or dead cells is obviously useless. Strychnine is tolerated in enormous doses in beri-beri, and so are arsenic and mercury. But a careful series of tests, and a very extended experience has led the writer to the conclusion that all these three drugs, Strychnine, Arsenic, Mercury, are like Digitalis, not only quite useless but prejudicial to recovery.

The writer's practice, after administration of the preliminary purgative—a hydragogue when indicated, and of atropine in urgent cases, is to put the patient on a mixture containing half-drachm doses each of Tinct. Belladonnæ, Tinct. Scillæ and Citrate of Potash, in four ounces of water, thrice daily for three or more days. After that time the belladonna may be omitted and tonics, bitters, &c., added. The treatment in later stages is that of a convalescent from any nerve disease. Feeding, massage, graduated exercise.

Prevention.

The prevention, the prophylaxis of beri-beri is the avoidance of stale uncured rice.

In countries where rice is grown in sufficient quantity no stale rice need ever be used. It can be made fresh from the *padi,* the raw grain, and so eaten day by day. *Padi* if stored properly, being kept dry, remains unchanged for an indefinite period, and so far as is known rice eaten when newly made from it is never noxious, however long it may have been stored undivested of its husk.

Where imported rice must be used, only that should be used which has been prepared by the method derived originally from Bengal which has been described as "curing." Cured rice according to abundant and impeccable evidence *never* produces beri-beri, however much of it be eaten, however old, stale, broken and even decomposed it may be.

When cured rice cannot be bought or made, and yet rice must be used, beri-beri may be avoided if only a moderate amount be given for a daily ration, and this be freely diluted with other proteid and fatty food. Thus in the Singapore Gaol which had from 1877 to 1885 been devastated by beri-beri so long as the ration of the prisoners contained an excessive amount of rice—some 20 oz. daily with little beside, the disease ceased to appear (at least in marked form) when the rice ration was reduced to no more than 14 oz. daily and a plentiful supply of meat, flour, vegetables and fat was given. This immunity from beri-beri lasted for twelve years. On the increase of the rice again to 19 oz. in 1897 beri-beri reappeared in this gaol almost as severely as before, and was only stamped out on the substitution, as the result of the writer's researches, of the stale uncured rice by cured rice at the end of 1904.

BERI-BERI AND EPIDEMIC DROPSY.

By Colonel KENNETH MACLEOD, M.D., LL.D.,

Indian Medical Service (Retired), Honorary Physician to H. M. the King.

During the past two years outbreaks of a dropsical disease have been observed in various parts of Lower and Eastern Bengal and Assam—in Calcutta and Howrah, Kurseong and Darjeeling, Dacca, Mymensingh, Comilla (Tipperah), Noakhali, Chittagong, Sylhet, Gauhati and Shillong. These outbreaks have occurred in a reformatory school (Alipore), a lunatic asylum (Dacca), in several gaols, in tea coolie lines and among the inhabitants of towns and villages. They took place mostly during the rains (June to August) and in some cases were prolonged into the cold season. They are described in the *Indian Medical Gazette* (1907, pp. 422,

435; and 1908, pp. 52, 53, 85, 124, 128, 167, 174, 182, 190, 237, 243, 273 and 327).

The localities visited have been to some extent the same as those in which outbreaks of a similar, if not identical disease appeared in 1877-78; but the area affected has been more extensive in the later than in the earlier invasion. Beri-beri is not known to exist as an endemic in the districts invaded, except to a slight extent among the Chinese resident in Calcutta; the occurrence as an epidemic outbreak of a disease presenting some features characteristic of beri-beri, and devoid of others which are held to be essential attributes of that affection, has given rise to much speculation as to the nature and causation of this malady. On this subject three opinions have been held—

1st, that the disease is beri-beri;

2nd, that the disease is epidemic dropsy and not beri-beri; and

3rd, that beri-beri and epidemic dropsy are the same disease, presenting in different cases and outbreaks variations of type more especially as regards the prominence of nervous and dropsical phenomena.

Bacteriological investigations have been made in cases of both beri-beri and epidemic dropsy without any positive result; and, in the absence of definite knowledge regarding the agency or material actually causing these diseases, whether the same or different reliance must be placed for purposes of comparative or differential diagnosis on epidemiological, pathological and clinical considerations requires consideration.

For this purpose I have drawn up a scheme founded on the articles describing the two diseases contained in *Allbutt and Rolleston's System of Medicine* (Vol. II, Part II, pp. 615 and 643) and on the papers which have appeared in the *Indian Medical Gazette*:—

	Beri-beri.	Epidemic Dropsy.
Geographical distribution.	Japan, Corea, China, Formosa, Manila, Malay Peninsula, Eastern Archipelago, Madras, Burma, Ceylon, Central Africa, Central and Southern America. Imported cases in Australia, Fiji, S. Africa and Britain common in ships.	Lower Bengal, Eastern Bengal, and Assam, Madras, Mauritius.
Season	Heat and moisture favourable. Prevails all the year round in tropical countries; in the warm season in subtropical.	Rains and old season.
Physical Geography.	Low-lying localities on coasts and rivers. Close valleys in hills.	Plains and hills up to 5,000 ft.
Epidemiology ...	Communities crowded under insanitary conditions most liable—gaols, coolie lines, ships, &c. Endemic and epidemic spread by man. Direct infection feeble or absent.	Habitations and institutions visited. Mostly epidemic spread by man. Immediate infection doubtful, probably whole household sometimes affected.
Causation	Unknown.	Unknown.
Incubation	Unknown, probably long.	Unknown, apparently short.
Invasion	Slow insidious in most cases.	Generally sudden and well marked.
Fever	Rare or marked intercurrent or accidental.	Initial and usual, remittent in type.
Gastro-intestinal disturbance.	Exceptional, bowels mostly constipated.	Diarrhœa common often initial and prolonged.
Cutaneous irritation.	Rare or absent.	Common (tingling, burning pain, &c.)
Cutaneous eruption.	Absent.	Common.
Dropsy	Secondary, apt to be partial, in some cases slight (dry beri-beri). Genitals not affected, not markedly subject to gravitation.	Initial or early, essential symptom cutaneous and sub-cutaneous, sometimes visceral, genitals affected. Subject to gravitation.
Anæsthesia	In every case, in patches or extensive areas.	Sensation sometimes dulled over dropsical area.
Paralysis	In most, if not all cases, wrist and foot drop atoxic gait, apt to be persistent.	Paresis from mechanical effect of effusion in some cases.
Knee jerks	Exaggerated in early stage, then lost in nearly all cases.	Sometimes exaggerated, lost in a small proportion of cases.
Nervous symptoms ...	Essential, initial, prolonged.	Unimportant or absent.
Anæmia	Absent.	Present.
Emaciation	Mostly muscular.	General.
Dyspnœa and Orthopnœa.	Common.	Common.

	Beri-Beri.	Epidemic Dropsy.
Sudden death ...	Frequent.	Rare.
Mortality	5 to 10 per cent. or over.	2 to 5 per cent.
Duration	Many months.	Some months.
Sequclæ	Persistent paralysis and muscular atrophy.	Emaciation, anæmia and dropsy.
Morbid anatomy ...	Degeneration of nerves and muscles, dilated heart, incompetent valves.	Effusions, congestions, and ecchymoses; dilated heart.
Pathology	A peripheral neuritis.	An Angeio-neurotic œdema (Lukis).
Blood	Normal.	Diminution of red corpuscles and hæmoglobin. Reduced coagulability. Leucocytosis.
Urine	Scanty, low sp. gr. reduced, solids, no albumen.	No albumen, marked indican reaction.
Temperature ...	Mostly normal or subnormal.	Generally raised. Œdematous areas warm and tender, temp. about ½ a degree higher than general surface.
Myalgia	Well marked especially in Sural muscles.	Absent or doubtful.

The various points contrasted in this table certainly go, in so far as they are valid and true, to establish the conclusion that beri-beri and epidemic dropsy are two different nosological entities and that the disease which has been observed in Bengal and Assam in 1877-78 and in 1907-08 is epidemic dropsy and not beri-beri. It must be allowed, however, that confusion in description and consequently in comparison has probably arisen from defective clinical observation. The term beri-beri has been very loosely applied to a great variety of maladies characterised by dropsical swellings and paralytic and atrophic symptoms and very possibly, nay probably, outbreaks and cases of epidemic dropsy—assuming a distinction between them—have been described under the former name and *vice versa*. The testimony of observers who have had experience of both diseases and made them the subject of searching clinical observation is therefore peculiarly valuable. This is supplied by some very interesting notes published in the *Indian Medical Gazette* (Vol. XLIII, p. 243) by Principal C. P. Lukis, M.D., F.R.C.S., based on cases of both diseases, observed and studied by him in the Calcutta Medical College Hospital and in private practice. Dr. Lukis unhesitatingly pronounces beri-beri and epidemic dropsy to be different diseases and concludes that the malady which prevailed in Calcutta in 1907-08 was epidemic dropsy and not beri-beri.

Another important contribution to the subject is the report of Captain T. H. Delany, M.D., I.M.S., who was deputed to investigate the prevalence of so-called beri-beri in gaols. Dr. Delany had seen and studied some five hundred cases of true beri-beri in Hongkong, and the result of his investigation of the outbreaks in Eastern Bengal and Assam was to convince him that "there is no beri-beri in the gaols of districts of Eastern Bengal and Assam and that none of the outbreaks of recent years were beri-beri." He further believes that the correct diagnoses of the outbreaks in these districts is epidemic dropsy, and he adds the interesting observation that "Epidemic dropsy has probably existed more or less in Sylhet and Shillong since the epidemic of 1878-79." (I. M. G., Vol. XLIII, p. 167). Observations made by Captain D. Munro, I.M.S., in the Darjeeling District point to the conclusion that the disease has for years prevailed in the tea gardens of that district. (I. M. G., Vol. XLIII, p. 124). Professor Leonard Rogers, I.M.S., who studied cases of dropsy which occurred epidemically in Calcutta in 1901, diagnosed them as epidemic dropsy and he considers the recent outbreaks to be manifestations of the same disease.

It is not my purpose in this communication to present an exhaustive analysis of the facts which have been recorded in the papers to which I have referred; but to invite discussion and stimulate further enquiry in regard to a subject of great scientific and practical interest and importance.

DISCUSSION.

Lt.-Col. H. M'Gill, R.A.M.C.—During September and October 1907 a number of cases presenting symptoms of the above disease were admitted from the British Infantry Regiment stationed at Poona. The Regiment was a fine body of men who had arrived in the station early in the year. Previous to these cases ten with somewhat similar symptoms had been treated between March and August. The disease occurred in an epidemic form in September, causing 21 admissions—17 in the first two weeks—continued during October when there were 20 cases and, rapidly declining in November and December to, respectively 7 and 3 cases, ceased entirely at the end of the year. Altogether there were 61 admissions which came from every company, but three furnished one-half of them. The disease was not limited to any particular age—15 occurring in men of 20—25 years, 29 in those between 25—30 years, 13 amongst men of 30—35 and 4 in others over that age. None of them were married and there were no cases amongst the women.

Many stated that they first noticed the symptoms of swelling and pain in the legs with shortness of breath on the morning of reporting sick, others that they had suffered from them for a few days with also an inability to walk any distance in comfort, whilst some admitted they had noticed the symptoms for several weeks but did not think them serious enough to report sick.

The cases can be divided into 4 groups according to the severity of their symptoms. (1) Twelve with only the following symptoms:—tachy-cardia, slight dyspnœa, shin œdema and weakness of the legs. (2) Twenty-three presented similar symptoms with also tenderness of the calves. In addition three had slight numbness of fingers and legs, 6 slight foot drop, 10 soft mitral or pulmonary bruits, 2 Romberg's

symptom, several disordered gait, 16 loss of knee jerk and others profuse sweating of hands and feet. (3) Eight exhibited the following symptoms :—tachy-cardia, dyspnœa, tremor of tongue and fingers, profuse sweating of hands and feet. weakness of legs, swelling and pain in calves, suffused face, restlessness, insomnia—occasional gastric irritation, loss of knee—jerk and shuffling gait. One had Romberg's symptom and another nystagmus on lateral movement of the head. (4) Eighteen formed this group, all with the following symptoms :—tachy-cardia, dyspnœa, shin œdema, swelling and pain in the calves and weakness of the legs. In addition, 15 had loss of knee jerks, 10 soft mitral or pulmonary systolic murmurs, 6 marked pulsation of the cervical vessels. 6 slight foot-drop, 7 numbness of calves, one cramp in the legs, 3 Romberg's symptom and one anasarca of the extremities, abdomen and face. The gait was disordered in all of them, shuffling, waddling, unsteady and in some high stepping. In none of the cases examined did the urine ever contain albumen. Of all these cases, one died and two were invalided. The remainder—6 of whom suffered from relapse—recovered and returned to duty after a month to six weeks in hospital followed by a similar period attending without duty or at a convalescent depôt. The fatal case occurred during September in a man 9 days in hospital for tachy-cardia, slight dyspnœa, shin œdema, pain in the calves and weakness of legs, who suddenly developed all the symptoms of acute cardiac insufficiency, *i.e.*, intense orthopnœa, great restlessness, profuse sweating, marked pulsation of cervical vessels, tumultuous action of the heart, and weak—very rapid uncountable—pulse from which he died after two hours. The following conditions were found at the autopsy :—

Pericardium full of clear fluid : Heart weighed 20 ozs. left ventricle hypertrophied, right dilated, valves healthy but mitral and tricuspid orifices much dilated. Lungs both very congested and œdematous especially at the base. Liver weighed 52 ozs. much congested and fatty. Spleen weighed 7 ozs. Kidneys weighed 5½ ozs. each, both were apparently normal. The stomach and duodenum looked healthy showing no congestion or ulceration.

It is quite evident that we are here dealing with a series of cases exhibiting, in varying degrees of severity, the symptoms of multiple peripheral neuritis caused by some toxin with a peculiar affinity for attacking the peripheral and vagus nerves. The toxins most likely to be implicated in the production of this pathological condition are those connected with (*a*) chronic arsenical poisoning, (*b*) chronic alcoholic poisoning, and (*c*) endemic neuritis or Beri-beri. (a) The claims of arsenic can be shortly disposed of since none of these cases presented the characteristic ocular, gastric or cutaneous symptoms seen in chronic poisoning by that metal, nor was any sample of the beer drunk by the men of the regiment, which would be the most likely vehicle for the introduction of arsenic into the system, found to contain, after most careful and independent analysis, more than the legal permissible minimum of 1/100 grain of arsenic to the gallon. (b) *Alcohol*—Can any evidence be shown supporting the suggestion that the outbreak under discussion was the result of excessive consumption of alcohol? I think the following facts will show that alcohol taken in excess was an important factor in the causation of the cases :—

1*st*. The History.—With few exceptions all the men admitted drank beer immoderately. None of them were teetotallers and, though some stated they only drank 2 to 3 pints a day, the greater number, certainly 50, confessed to having regularly drunk 6 to 8 pints daily, not a few of them admitting to as much as 2 gallons, whilst several drank 3 gallons whenever they could get it. The larger amounts seem enormous, but the men always adhered to their original statements. Now, what does the consumption of this amount of beer represent *qua* absolute alcohol? Careful analysis conducted by the Divisional Sanitary Officer and the Director, Central Excise Laboratory, Kasauli, showed that all the samples of beer drunk by this Regiment contained 5·6—5·7· vol. per cent. of absolute alcohol—so that a man who drank from 6 pints to 2 gallons of it consumed 6·7—17·0 ozs. of 100 per cent. alcohol, whilst the 3 gallon men took nearly 26·5 ozs. In the opinion of the Director of the Central Excise Laboratory "the consumption of such large daily amounts of alcohol would suffice to account for all the symptons described."

2*nd*. The Symptoms.—Any one who has seen a case of multiple alcoholic neuritis—which is not very uncommon in the army—would at once recognise the similarity of many of the symptoms present in it with those I have described in this series of cases. Bain in his text-book of Medical Practice gives a clinical picture of a case of a multiple alcoholic neuritis—in which he describes the occurrence of the following characteristic symptoms :—

Formication or numbness in fingers and feet, pain in legs increased on movement, tenderness of the calves on pressure ; foot drop, tremor of tongue and fingers, high stepping or waddling gait ; tachy-cardia, dyspnœa and œdema along shins, loss of knee jerk, profuse sweating of hands and feet, anæsthesia of lower extremities rarely spreading to the trunk. When speaking of the prognosis of these cases he remarks: "Alcoholic cases usually recover completely although it may take months or years for them to do so. There is, however, a constant danger of sudden death in severe cases, an event that has been attributed to neuritis of the vagus leading to cardiac failure." In support of this statement, I have notes of two cases from different Corps that were carried into the station hospital with all the symptoms of acute cardiac insufficiency. Both died a few hours after admission. In each the pericardium contained some fluid. The heart was enlarged weighing 16 ozs., right ventricle much dilated, left hypertrophied, valves healthy but mitral and tricuspid orifices dilated, tissue fatty and very flabby. Lungs both much congested and œdematous. Liver fatty and enlarged weighing 72 and 76 ozs. Spleen weighed 8 ozs. very dark coloured and soft. Kidneys weighed 7½ and 7 ozs. very fatty and congested. Stomach and duodenum congested but not ulcerated. Both these men were habitual heavy drinkers. One was of most active habits, the other never took any exercise : neither had ever reported sick and no evidence could be obtained of their ever having complained of feeling unwell before they were carried to hospital, Osler also draws attention to a group of cases of dilatation and hypertrophy of the heart occurring in men who do very hard work and at the same time drink alcohol, chiefly beer, to excess, They report sick complaining of palpitation, shortness of breath, slight anasarca of lower extremities, pains in legs and later often develop symptoms of cardiac insufficiency, I may mention that nearly all the men who suffered in the manner I have described were of most active habits regularly taking part in hockey, foot-ball, cross country races, and gymnastics. I think it will be allowed that the evidence brought forward as to the intemperate habits of a large majority of the sufferers gives colour to the supposition that alcohol taken in excess had a great deal to answer for in the causation of this out-break of multiple peripheral neuritis. There is, however, a feature in the history of the out-break that cannot be reconciled with the theory that it was entirely due to alcohol. I refer to the epidemic character it assumed during September and October. Closely as the cases described resemble alcoholic multiple neuritis, I have never known nor heard of that disease appearing in an epidemic form. So it is evident that some other toxin was primarily or secondarily responsible for this outbreak. The most likely one is the unkown toxin that is responsible for the occurrence of Endemic Neuritis or Beri-beri.

(a) *Beri-beri.*—There is no doubt that the symptoms described resemble those attributed to the toxin or germ of beri-beri, but if the outbreak was that disease it was in most cases of the larval type. Some had more severe symptoms, one—the fatal case—was pernicious, whilst others in group "4" with pulsation of cervical vessels, tachy-cardia, bruits, dyspnœa and general discomfort were allied to that type. None belonged to the "dry or paralytic" form with marked

paresis and muscular wasting, nor excepting one were there any of the "wet or dropsical" type with general anasarca.

Dr. Joseph Benjamin said.—He had seen in April last a case of epidemic dropsy, a Hindu, at Bhaner, in the Kaira district. Two members of his family had died of the same disease before him. Two other cases had occured in another family. Besides, three other persons in the village had died, and another was suffering from the disease, when the above patient came under observation. A few cases were also reported to have occurred at the villages of Jalia and Fenai in the same taluka. In the Ahmedabad Civil Hospital also a few cases were treated last year, among whom were three belonging to one family. The cause of the disease is still shrouded in mystery. Captain Delany, I.M.S., is of opinion that it is a specific infectious disease conveyed through the agency of the bed-bug. The reasons given by him for its being of bacterial origin are :—(1) its epidemic character, (2) its initial fever, (3) the rash, (4) the local or house infectiousness, and (5) the sudden disappearance of the disease when infected houses are vacated. Col. Campbell, I.M.S., thinks it is a disease caused by a fungus growth on the rice, and that it is not communicable from man to man nor by an intermediate host. It may here he noted that Bajri was the staple food of the patient seen by me and of the other cases that occurred in the village. The duration of this disease is from 2 to 12 weeks or more. In this the symptoms were dropsy with emaciation of the limbs, weak pulse, exertion on walking, knee-jerk undisturbed, dryness and irritation of the skin, pain in the legs, aching of muscles, bones and joints, scanty urine containing phosphates in excess but no albumen, loose bowels, and history of fever in the beginning, dropsy rapidly supervening with emaciation. There was no history of rash in the case. There was also no enlargement of the liver or spleen but his heart sounds were found weak and quick. Nothing wrong was found with his lungs at the time of examination.

Professor Musgrave said.—He wanted to make it quite clear that he had a perfectly open mind on the subject. He had no pet theories as to the cause of the disease, but he had been particularly interested in the subject for fifteen years. He approached the subject from the standpoint that all the various investigators had made careful observations. Was there any way of harmonising their differing conclusions ? They would remember that in the case of malaria, before the discovery of the parasite, there had been a heterogeneous mass of varying theories, and yet when the parasite was discovered they were all explained, and, just as simply, he believed, when the time came for the real cause of Beri-beri to be discovered all the conflicting views would be explained. They had been engaged upon experiments regarding the disease at Manila for twelve months, and as a result he would offer as a working hypothesis which he thought would harmonise Mr. Braddon's idea and all the others. This was that the disease was due to some Micro-organism. It must be some organism that would stand boiling because the rice was boiled before it was eaten, but they had discovered a series of organisms which would stand boiling. Possibly, then, they might discover such an organism which would cause the disease.

Dr. Arthur Powell said.—It appears to me a much better working hypothesis would be that Beri-beri is caused, not by an infection, but by an *intoxication.* Not one of the numerous claims to have discovered an infective organism had ever for a moment stood the test of experiments by independent observers. In infective diseases we find, as a rule, a fairly definite period of incubation, and in many a fairly definite duration. Not so in Beri-beri which is in the main a peripheral neuritis. We know we can produce a very similar disease with such poisons as alcohol, arsenic, antimony and other drugs.

Beri-beri shows a very striking parallel to alcoholic and chronic arsenical peripheral neuritis. There is no definite period of incubation, no definite length of course which the disease will run. The incubation and duration of all three diseases—I would say intoxications—depend on the size of the doses and the duration and persistence of their administration. Leaving out of consideration the idiosyncracy and state of health of the subject the onset can be hastened and the duration prolonged by pushing the dose.

If Dr. Braddon's statements be accurate—and Sir Francis Lovell who has just arrived from the Straits informs me that the most sceptic of Dr. Braddon's former opponents are convinced of the correctness of his conclusions and of the accuracy of his facts,—we can have no possible doubt, no shadow of doubt whatever, that *in his numerous cases* the disease was caused by the ingestion of the particular form of uncured rice which he describes.

Colonel M'Gill has proved with almost equal certainty that rice was not the causative factor in his cases. Most probably it was alcohol.

On the evidence which Dr. Braddon has brought forward no jury or court of law would fail to convict that particular rice.

As the rice had been cooked by prolonged boiling immediately before consumption, any but a phenomenally hardy organism would have been killed. Its toxin might, however, retain its poisonous properties.

We know that one fungus can live in grain and there produce a toxin capable of giving rise to a peripheral neuritis. Boiling kills the fungus, but does not destroy the poison. I refer to the yeast plant and its toxin alcohol. We call the disease alcoholic peripheral neuritis, a chronic intoxication, not a "Torula Infection."

We also know that in other epidemic diseases arising from the ingestion of grain foods, such as Lathyrism, Pellagra, Ergotism, the incidence of the disease falls upon the nerve system but on other than the peripheral tracts.

In Ergotism and Pellagra we know for certain that the diseases are not infections, but intoxications by ergotin and pellagrozein respectively.

I would therefore with all deference offer as a working hypothesis for the etiology of Beri-beri, epidemic dropsy and allied forms of peripheral neuritis that they are not infections but intoxications, and that probably there is more than one toxin, thus accounting for varieties of the disease in different epidemics ; for instance, one toxin may affect the vaso-motor apparatus more than another and so produce "wet" and "dry" strains of the disease.

In epidemic dropsy the variety of toxin affects the vaso-motor nerves most severely. The toxin, arsenic, especially attacks the trophic nerves of the skin, hence the pigmentation and hyperkeratosis characteristic of this form of peripheral neuritis.

It is probable the toxin is manufactured by a bacillus or other fungus. But in that case its factory is certainly outside the human body as in the case of ergotin, alcohol and pellagrozein. Where only a single case was seen such as that recorded by Dr. Benjamin the diagnosis of "Epidemic dropsy" was open to grave doubt. There was no rash. A suspicion of ankylostomiasis had not occurred to Dr. B. At all events he made no mention of any examination of the stools. In many cases in E. Bengal, diagnosed as Beri-beri or Epidemic Dropsy by my colleagues I have found many ankylostomes, to which I have attributed all the patients' symptoms. In the recent cases quoted by Col. Macleod, definite information on this point was lacking. We should remember that twenty years ago, ankylostomiasis was officially known as the "Beri-beri of Ceylon."

Dr. Varis said:—Much has been written regarding the alleged production of Beri-beri by the ingestion of decorticated rice, that is to say, the white variety deprived of its pericarp and proteid layer, and in a stale condition, the poisoning becoming existent after decortication but not before. The poison thus produced is held to be of the nature of ptomaine poisoning. This is said to be the outcome of the formation of ferments or enzymes acting only in solution and the product of a specific fungus in stale rice. It is the peripheral nerves that are specially concerned in the morbid process resulting.

Eijkmann has closely studied the manifestations of Beri-beri amongst numerous prisoners in the Dutch Indies with special

reference to this theory ; and he holds that the grain contains a poison acting in the way aimed, but contained in the seed itself and not in the coverings. He has made a series of interesting experiments on fowls, with a view to confirm his theory of the poison being peculiar to the rice seed and separate from the whole grain or raw paddy, and of the natural antidote to the seed poison being in the coverings of the grain ; and he was able to produce a form of peripheral neuritis in these fowls by feeding them only on decorticated white rice, but never when he made them exclusively consume the grain partly covered by its pericarp—the red rice—or on paddy or whole rice. No matter what the source of the rice, the fowls made a satisfactory recovery from this disease, which resembled Beri-beri in its pathological anatomy, symptomatology, and irregularity of evolution, in due course when he changed the white rice for the red variety, or when he added husks or pericarp to the former. This theory of the poisonous character of the grain and the antidotal nature of its coverings, as investigated by this observer, has been much criticised and the accuracy of his methods and the general technique of his experiments impugned.

The 1897 epidemic of Poulo Condore is one of the observations that has been adduced in opposition to such theories as that of Eijkmann, where, the prisoners, being fed on the kind of rice that in the terms of this theory should be innocuous, suffered severely from Beri-beri.

Travers also objects to the rice theory after having observed in three institutions in Selangor, all supplied with identical rice from the same source, a severe outbreak of Beri-beri in one and no sign of the disease in the other two. This inconsistency Braddon explains on the ground of the relative quantity of rice consumed, it being less, he says, in the institutions that escaped the disease.

Ellis also refuses to subscribe to the rice theory after an observation in 1900 of the disease on a steamer en voyage from Singapore to Australia, on board of which there was a crew of 28 Malays and 51 Chinese. "All," he says, "were fed on Siam rice, cooked in the same manner, and in one galley. In cold weather, near New Zealand, Beri-beri broke out in the starboard forecastle, inhabited by 14 of the Malays, and in all there were 8 cases and 5 deaths. This forecastle had the galley situated immediately aft, with but a thin wooden partition. The heat from the galley caused the cabin to be always sweating and steaming, as it was somewhat wet from the bad weather experienced at the time, and, in fact, converted into a perfect incubating chamber." After embarking, he says no food was eaten, or stored, in this place, that disinfection was carried out at his instigation, with the result that the disease was checked; and he adds that had "the rice been in fault, it is difficult to understand why the eight cases occurring should have all been among fourteen men occupying one cabin, and that the remaining hands should have entirely escaped." The same author narrates another experience concerning an outbreak of the disease amongst some lunatics fed according to European ideas. It appears that, in 1890, he "separated twenty healthy native patients on admission in two cottage blocks, giving them European food, and no rice whatever. At that time, though Beri-beri was very prevalent amongst the natives, we had never had any cases among Europeans or Eurasians, and I wondered if in any way the food was in fault. My experiment had to be given up in less than three months, as more than half of the cases had by then developed symptoms of the disease. The opinion I then came to was that Beri-beri was a place-disease, that the soil and buildings were infected, and that people dwelling there were liable to absorb the poison, whatever it was, that this absorbed in sufficient quantity was the cause of Beri-beri, and this opinion I have never seen reason to change.'

Various writers have regarded Beri-beri as a form of poisoning by *arsenic*, particularly amongst the workers in certain mines, minute doses of the metal being capable of producing certain suggestive symptoms. But analyses of the urine of Beri-berics have not always shown even a trace of arsenic. Beri-beri has not been observed amongst certain mountaineering people who habitually consume the drug, and the latter is actually a safe and salutary treatment for the very disease which it is supposed by the advocates of this theory to cause. The hypothesis may, then be dismissed forthwith as untenable.

Defect in *nitrogen* is one of the numerous other theories that have been advanced to account for the occurrence of Beri-beri, and has had a great vogue in Japan and elsewhere. The case of the Japanese Navy has often been cited in support of this nitrogen-starvation theory, it being insisted that from a Beri-beri morbidity of one-fourth of the sailors previously existing, the affection is now almost unknown amongst them : and this, too, since the addition of more nitrogenous elements to the dietary. Nevertheless, I regard this great improvement as due to rearrangement of the hygienic conditions on up-to-date lines of perfection, and, so far as amplitude of nitrogen is concerned, as a mere coincidence. The theory cannot explain the restriction of the disease to certain houses in the midst of communities all fed alike, the occurrence of Beri-beri amongst both the poor and the affluent classes of society, and such other factors as the geographical prevalence of epidemics. The idea is well illustrated by the Singapore Prison epidemic, in which both the male and female sides were fed alike and consumed the same water, and yet the former class suffered severely, located as they were under conditions of dampness, and the latter entirely escaped the Beri-beri.

Let us now consider the *microbic origin of Beri-beri*, a view of production of the disease that is being supported by an ever-increasing array of observers.

The theory of *infection by a telluric miasm or toxin* is one that has been fathered especially by Sir Patrick Manson who holds that Beri-beri is occasioned by the absorption by man of a saprophytic organism from the earth, interior of houses, etc., and that, in this manner, and after the style of the alcoholic disease, there is produced in time a peripheral neuritis. "The soil", he says, "is the infecting medium ; the man residing on it is poisoned, not infected. In the case of aboholic neuritis—so like Beri-beri—the germ of the disease is the yeast plant ; the culture medium, the saccharine solution ; the toxin, the alcohol. The alcoholic germ may be swallowed with immunity ; not so the toxin which it generates. So with Beri-beri : its germ lives in the soil : it produces some toxin there : and this toxin, being inhaled or swallowed by man, produces in him a specific neuritis ; and, just as man can carry the yeast plant from one place to another, so may he carry the Beri-beri germ. So far as I have been able to interpret them, this is the only hypothesis which fits in with all the facts of the case."

This is, of course, a mere theory by our author advanced without substantiative evidence ; and there have been some who have affirmed that if the germ of Beri-beri lives in the soil those who walk on it with sores on their feet would be more affected than others who do not. This has been observed occurring in natives by Reacur, who also emphasizes the frequency of the disease in those having operation wounds on their bodies, *i.e.*, surgical Beri-beri.

Hamilton Wright holds that Beri-beri is caused by a germ which in some way or other gets into the system, and then gives rise to morbid processes, particularly in the pyloric and duodenal regions ; in this way a toxin is produced which exerts a malign influence on both the efferent and afferent peripheral nerves, the central nervous system being secondarily affected. This germ may be expelled from the body of the host with the motions, and so infect the soil, houses, furniture, and other appurtenances of the poverty-stricken unclean ; it may also get into water or be carried about by dust, although the organism perishes rapidly under the influence of light, thus accounting for the localised outbreaks in prisons, mines, and other dark places where the vital conditions are favourable. He refuses to subscribe to the rice theory, in spite of the numerous facts that have been advanced in support of it.

For prophylaxis, change of residence, regulation of diet and disinfection should be relied on.

There is no specific remedy for the disease—dieting, nursing hygienic and symptomatic measures being the essence of the treatment of any given case.

As in other affections, the diet of the Beri-beric is of considerable importance. It should be as nutritious as is compatible with its digestibility. It should comprise a liberal amount of nitrogenous, fatty and albuminous material, and be thoroughly cooked. The alleged origination of the disease in nitrogen-starvation is not without significance. The food should approach the European standard in as far as is consistent with the climatic conditions under which the patient exists. Dyspeptic and other alimentary troubles will, of course, call for modifications on general principles in accordance with indications.

Drugs.—As already stated I know of no drug that will cure Beri-beri, though some of them are not without influence in relieving urgent symptoms.

LEPROSY IN JAPAN.

BY PROF. K. SHIGA.

Historical.—According to Prof. Dohi's views, leprosy occurred first in India and then made its way into the western countries, then extended into China, (400 B. C.), Oceania and Corea, then came to Japan. History shows that leprosy existed in Japan about one thousand years ago. An old Japanese medical book, the "Daido-Ruishi-Ho," as Papirus Eberus, well described leprosy. In the era of Suiko Emperor, 612 A. D., white leprosy was recorded, and people generally thought that leprosy was a dangerous disease. It is impossible to know how many lepers there were at that time. The present number of lepers is estimated at about 30,000 in all Japan. It is probable this estimate is less than the real number.

The most interesting point in the primary period of the outbreak of leprosy was that the infectious power was very strong, and spread at once, but after years the infectious power was gradually destroyed. For instance, the leprosy epidemic of Europe of the middle ages is now stamped out. The first case occurred in Batavia in 1655 and spread rapidly. A great many cases occurred, however, at the middle period of the 19th century. About that time, the infection-theory changed to heredity-theory. Leprosy was first brought to Hawaii in the middle of the 19th century, and spread so rapidly that in a short time about 1/10th of the population became lepers. Recently, their numbers are decreasing. In ancient time the people of Japan thought that leprosy was an infectious and epidemic disease. At the period of Ashikaga, 14th century, the infection-theory changed to heredity-theory, and this heredity-theory was still believed by all the people until the recent investigation and study of bacteriology. Prof. Dohi says, that in Memel in Germany and Hawaii many cases were found of tubercular leprosy, but in Japan very few cases were found, but on the other hand many cases of nervous leprosy were discovered. Pathological and bacteriological investigation shows that nervous leprosy has no strong infectious power, but tubercular leprosy has very strong power of infection. It seems to be that the leprosy occurring first, was the tubercular form, and very abundant, and after years the virulence gradually decreased, and appeared in the nervous form. Thereby it can be said that tubercular leprosy has existed in many cases in ancient Japan. History shows that in the era of Nara, at the beginning of the 9th century, the Empress Ko-myo had established a Leprosy Hospital in the vicinity of Nara. This was the first sanatorium for lepers (or Lazar-house) in Japan, and the record tells that the Empress in her mercy has washed the leper's hand herself.

At that time, sanatoria (or Ryo-yo-in) and dispensaries (Sey-yak'-in) received the poor people and many lepers. Later on, the abhorrence of the people against the disease made the lepers isolate in one place like the real leprosoria. These leprosorias existed at Nara and Kyoto until the Tokugawa period (40 years ago). At present, 10 leprosorias or leper-asylums are in Japan, many of them under private control and 4 of them established by Christians' hands. They are as follows :—

1. I-hai-en, Tokyo.—Established in 1894 and yearly subscription is 20,000 Yen paid by a benevolent society, Leprosy Mission of Edinburgh, Scotland. Lately a contribution of 30,000 Yen has been offered by the charitable public. The present number of lepers in the Asylum is 50.
2. Kamiyama-fukusai Hospital, Shizuoka.—Established by a French Missionary, in 1888. Mr. Bertrand now takes charge. It contains 11 lepers at present.
3. Quai-shun Hospital, Kumamoto.—Established by Miss Riddel in 1895. At the present time it contains 46 lepers.
4. Tai-ro-in, Kumamoto.—Established in 1896 by a French Missionary. It contains at present 29 lepers.

Quite recently the Government of Japan formed a plan to divide the country into five parts, and in each of these a public asylum should be constructed, in order to make the isolation and treatment of all lepers effective. This governmental bill will take effect this year.

The report of the Sanitary Bureau of the Japanese Government shows that in 1906 there were 23,815 lepers, the leper families were estimated to be 22,887, all through the country. We get, therefore, 5 lepers per 10,000 population, and 25 lepers per 10,000 families. The number of lepers per 100 families will be 104. This shows that it is very rare to find more than one leper in a family. The families which hold lepers are estimated

to comprise a total of 102,585 individuals. The percentage of lepers in these families will be 23·3. Sexual proportion of the lepers corresponds to 43·4 females per 100 males.

LEPROSY IN JAPAN 1904.

PREFECTURES.	NUMBER OF LEPROSY.		Total.	Leprosy families.	Persons of leprosy families.	Number of Total households.	Number of populations.	4·6 (°/00)	5.7 (°/00)	3·7 (°/00)	Per cent. of female to male leprosy.
	Male.	Female.									
	1	2	3	4	5	6	7	8	9	10	11
Hokkaido	212	90	302	490	2,535	211,633	1,120,584	2·32	2·26	0 24	42·4
Tokio	120	50	170	129	544	607,165	2,671,546	0·21	0·20	0·06	41·6
Kioto	133	56	189	151	524	220,383	992,412	0·69	0·53	0·19	42·1
Ohsaka	298	112	410	368	1,324	385,792	1,860,245	0·95	0·71	0 22	37·5
Kanagawa	128	77	205	195	730	112,885	627,057	1·72	1·16	0·27	61·5
Hiogo	506	139	645	1,150	1,570	337,785	1,584,598	3·40	1·34	0·41	27·4
Nagasaki	453	193	646	604	2,560	176,180	1,034,916	3·43	2·77	0·62	42·6
Niegata	373	218	591	514	2,187	473,279	1,692,056	1·09	1·66	0·35	58·4
Saitama	193	88	281	257	1,437	207,684	1,246,607	1·24	1·15	0·23	45·5
Gumma	391	222	613	432	1,969	140,109	901,269	3·08	2·17	0·65	56·8
Chiba	334	158	492	427	1,943	222,247	1,339,418	1·92	1·45	0·37	47·3
Ibaraki	257	105	362	335	1,758	203,443	1,197,668	1·65	1·47	0·30	40·9
Totsuki	311	115	426	430	2,382	158,015	871,492	2·72	2·73	0·49	37·0
Nara	195	98	293	387	1,858	103,076	523,185	3·75	3·55	0·56	56·3
Miye	360	156	516	478	3,551	194,482	955,222	2·48	2·67	0·54	43·4
Aichi	668	245	913	883	3,586	356,986	1,794.033	2·47	1·99	0·51	36·7
Shizewka	528	225	753	606	2,884	219,781	1,289,343	2·76	2·23	0·59	42·6
Yamanashi	191	61	252	244	1,325	99,546	545,076	2·45	2·47	0·46	31·9
Shiga	223	83	306	284	1,342	131,624	739,368	2·16	1·81	0·41	37·2
Gifu	494	159	653	589	3,375	197,179	983,347	2·98	3·13	0·66	32·2
Nagano	263	131	394	364	1,483	254,645	1,301,765	1·42	1·13	0·30	49·8
Miyagi	297	182	479	411	2,211	137,373	827,100	2·99	2·67	0·57	61·3
Tukushima	343	176	519	459	2,567	198,265	1,169,936	2·31	2·19	0·44	51·3
Jwate	3	3	3	553	2,928	118,677	144,243	4·65	3·93	0·34	52·3
Aomori	447	173	620	542	3,070	98,877	659,575	5·48	4·63	0·94	38·7
Yamagata	243	114	337	329	1,853	137,191	810,413	2·39	2·28	0·44	46·9
Akita	274	130	404	322	1,937	128,011	838,954	2·51	2·30	0·48	47·5
Fukui	176	72	248	233	1,019	122,317	589,275	1·90	1·72	0·12	41·0
Ishikawa	117	56	173	162	756	152,207	753,728	1·06	1·01	0·23	47·9
Toyama	91	27	118	109	540	145,418	781,016	0·74	0·69	0·15	29·7
Tottoavi	129	54	183	170	720	88,892	424,6[illegible]8	1·91	1·69	0·43	41·9
Shimane	241	92	333	274	1,055	147,265	725,125	1·18	1·45	0·32	38·2
Okayama	339	110	449	412	1,422	246,688	1,124,653	1·67	1·26	0·40	32·4
Hiroshima	303	107	410	373	1,469	294,699	1,460,000	1·07	1·01	0·38	35·3
Yamaguchi	472	171	643	575	2,552	218,457	1,032,315	2·62	2·47	0·62	36·3
Wakayama	186	68	254	233	1,144	140,711	638,993	1·56	1·79	0·40	36·6
Tokushima	298	121	419	406	2,014	125,771	706,365	3·22	2·85	0·69	40·6
Kagawa	271	72	343	327	1,478	123,442	596,484	2·45	2·48	0·58	26·6
Ehime	489	183	672	619	2,373	194,180	1,032,096	3·19	2·30	0·63	37·4
Kohchi	320	115	435	393	1,428	127,674	648,907	4·84	2·20	0·67	35·9
Fukuoka	579	263	842	732	3,291	302,931	1,553,254	2·42	2·12	0·54	45·4
Ohyeda	652	260	912	850	3,354	146,580	743,650	5·79	4·51	1·22	39·9
Saga	355	194	549	495	2,262	111,102	624,049	4·46	3·62	0·88	54·6
Kumamoto	1,256	631	1,887	1,743	8,822	218,919	1,163,199	7·96	7·58	1·62	50·2
Miyasaki	572	241	813	733	3,208	104,157	519,947	7·03	6·17	1·56	42·1
Kagoshima	1,085	586	1,671	1,492	5,620	220,021	1,222,578	6·76	4·59	1·36	53·9
Okinawa	441	229	670	624	2,585	100,511	499,114	6·21	5·18	1·54	51·9
TOTAL ...	16,607	7,208	23,815	22,887	1,02,585	9,164,273	47,161,403	2·50	2·18	0·50	43·4

Let me report the general summary of my bacteriological research on this disease.

Cultivation.—I have tested with all the known culture media for the cultivation of the lepra bacillus. Salt-free media, which were prepared from roast-beef under high temperature steam treatment were tried with negative results. Emil-Weil's medium (An. de l' Institut Pasteur, No. 12, 1906) (Sea-water 75, Aq. dist. 250, glycerine 40, grape-sugar 8, peptone 10, agar-agar 20, with $\frac{1}{4}$ yolk of an egg, reaction slightly alkaline) was used many times. There appeared a temporary growth as Weil describes, but no colony grew. Therefore this will not be a successful culture medium for the bacillus, because other culture media show just the same results. Healthy human serum, leper's serum, human organs, namely, liver, spleen, brain, bone-marrow, and fat-media digested

with trypsin and pepsin were all negative. However increase of the bacilli was noticed many times, during 2 to 7 weeks after inoculation. I inoculated recently a fresh leprous-tubercle on potato-glycerine-agar with human serum. Four weeks later a peculiar colony grew on the medium. Microscopically it resembled pseudo-diphtheria bacilli, but more slender and longer. They discolored by acid but many of them resembled the lepra bacilli. I first thought that the bacilli might not be a pure culture but the result of symbiosis; after many generations the colonies were pure, and never lost their acid-fast character. If incubated for 2—3 weeks the acid-fast bacilli gradually decreased and then expired. These bacilli grew as a pale yellowish membrane with wrinkles like the Streptothrix Madurae on agar culture. The Agglutination test was not certain, leper's serum and healthy serum reacted about the same. Cutaneous inoculation test with the bouillon culture in lepers reacted more distinctly than in a healthy person. But the control test with tuberculine had a little stronger reaction. Cultivation from the leprous organs (almost always impure) could not be cultivated with many materials for culture media. I could not succeed with inoculation into the animal body, later I tried other methods. For example, leprous organs were put in a lecithin solution, and kept for 1-2 days. Then the mixed bacteria died and the organs became easily crushed. Therefore, I consider this method helpful. I believe that the lepra bacilli do not alter in the lecithin solution, even after a few days, as I proved with the tubercular bacillus.

Animal Experiment.—This was done with the purpose of protecting the germ against phagocytosis in the animal. I crushed the leprous tubercles, put into a collodion-bag, or bamboo-sheath, and inoculated into the intraperitoneal cavity of a guinea-pig, then after a few weeks the material is changed to a new bag, and inoculated in a second guinea-pig's intraperitoneal cavity, &c. This experiment showed that lepra-bacilli are gradually decreasing and broken up. For protection against phagocytosis, lepra bacilli were inoculated subcutaneously into the ear, or toe of rats and rabbits, but the results showed that they were absorbed 1 to 2 weeks after inoculation. In the other experiment the leprous organs were crushed with a glass-rod and applied to the nasal mucous membrane of a monkey, but this result was negative too and inoculation in the abdominal or intercostal muscles showed that they were gradually absorbed. In one experiment when the pectoral muscles were inoculated the animal died from other causes five weeks later. The autopsy showed many yellowish tubercles existing in the muscle-fibre around the part inoculated and showed numerous lepra-bacilli in the tubercles. An experiment by direct injection into the monkey's testicle was negative, and also an experiment on the orang-outang, result—the same as Prowazek's communication—negative.

THE DIFFERENTIATION OF LIVING AND DEAD BACILLI OF LEPROSY IN TISSUE BY DOUBLE STAINING.

By Professor P. G. UNNA, M. D.

As now-a-days the local and general treatment of leprosy is carried out with greater energy and more success than formerly, the question necessarily arises :—*Do we possess a means of determining whether in excised tissue the leprosy bacilli are living or dead.* Since all practitioners are now convinced that the leprosy bacillus is the real cause of leprosy, although infection has never been produced by pure culture, clinical methods alone are not sufficient for determining improvement and cure in a case of leprosy.

We must rather bring forward proof in each case that the bacilli have markedly diminished in number and, when possible, completely disappeared, in excised portions of the skin which earlier appeared affected by leprosy. The leprosy bacillus itself facilitates this kind of investigation from the fortunate circumstance that, on account of the chronic nature of the disease, the bacilli are always numerous, sometimes present in enormous masses, so that, in successive excisions, an alteration in their number cannot be disputed.

If one undertakes an investigation of this kind, naturally the first endeavour will be to demonstrate every bacillus in the section by a strong bacillary stain. We know from experience that the number of visible bacilli in the sections increases with the intensity of the stain and this again depends in great part on the personal skill and practice of the investigator. Comparative studies on the number of bacilli as an indicator of the improvement of a case of leprosy, are only valuable if they are carried out by the same investigator and with exactly the same methods.

What is the merely relative value of a single stain due to? this point was cleared up long ago. Ehrlich, 23 years ago, showed for the first time in the case of tubercle bacilli in sputum that stained bacilli respond very variably to decolorising processes. The bacilli age in the tissues and slowly die off; indeed, the older and weaker they are the slighter their resistance after staining to the process of decolorisation by $H\,NO_3$ or in other words, the "acid fastness" of tubercle bacilli is variable and diminishes with the age of the bacilli. By careful investigation we detect weaker stained bacilli close to normal deeply stained bacilli.

What Ehrlich found to be the case for the "acid fast" tubercle bacillus applies in a much higher degree to the leprosy bacillus, which has very similar staining properties. Whilst we find in the tubercular sputum and

lungs only single faintly stained bacilli, the leprosy bacillus forms colonies in the tissues which generally consist in part of dead bacilli. The fact that the technique determines the proof of the number of bacilli, applies with much greater force to leprosy than to tubercular cases. The numerous dead bacilli are faintly or not at all visible with the Ziehl stain ; these slightly or non-acid fast bacilli have played a peculiar part in the pathology of leprosy. Formerly the colonies of bacilli were regarded universally as cells with degenerated vacuolated protoplasm, because they take the acid stain in moderate degree. When I, in 1892, discovered the fat content of the leprosy bacillus (published for the first time in my Histopathology of the Skin, 1894) it was shown that these dead bacilli, which surround the well stained bacilli, contain some but much less fat. They were on this account considered by others to be fatty degenerations of the protoplasm of the connective tissue cells.

According to the majority of investigators, a collection composed entirely of normal dead bacilli was found in the Gloea (a name given by me to a mucoid substance containing bacilli) occurring as well-staining clumps and in the so called Globi only. As a matter of fact the leprosy organism includes a large and varied series of forms, which not only includes the known bacilli and globi, but also others, different in morphology and staining reaction, and transitional forms which are inseparable from the growth of the leprosy bacilli in the skin. I will not enter further into the peculiar morphological shapes, coccus-like granules, and granular threads (coccothrix), which were found in my laboratory by Lutz[1] (1885) and studied more closely by me[2] and my pupil Spiegel[3] and which Much[4] has by experimental investigations lately studied and determined the biological significance of. The granules simply represent, as pointed out in 1886, the nucleus of the leprosy organism. The leprosy bacilli, which are distinguished by their being acid fast and having a rod shaped form, surround, like a capsule, the leprosy organism. On account of the leprosy bacilli being easily demonstrable they have been generally regarded as the leprosy organism itself. These growth forms of the leprosy organism which apparently are well suited to the human tissue are distinguished from the tubercle bacillus by their morphological structure and viability. If the leprosy bacilli lose their " acid fastness " they are not dissolved at once, but remain as rod shaped forms, as shadows of rods, for a long time, and adhere to one another forming round oval or cylindrical clumps, which surround the well staining bacilli as a capsule. In order to demonstrate the rod like shape of the former, a special staining method (which I published in 1898[5] and 1906[6]) is necessary. It is now recognised that the normal and dead bacilli are fused into a bacillary clump always unstainable and appearing as a transparent space containing areas, regarding which it remains uncertain, whether they, like the remaining Gloea, contain the remains of bacilli or are to be regarded as an amorphous glassy substance or as vacuoles without substance and filled with lymph. In my work on the composition of the mucoid of leprosy bacilli I stated the position of the problem then as follows :— I am not yet in a position to state what the remaining vacuoles are which take neither the Kollagen nor Gloea stain, whether lymph or coagula or whether a peculiar complete mucoid degeneration of Gloea without the remains of bacilli. This is the next problem to be solved in the microscopic study of the leprosy bacillus.

During the past ten years I have followed this question at every opportunity and have come to the conclusion, by new, and, in my opinion, accurate methods, that the unstained structure of the Gloea is a peculiar mucoid, badly staining substance which is secreted by the leprosy bacilli and surrounds them, and in the colonies exerts a peculiar mechanical action. After having described the individual components and phases of growth of the leprosy organism we proceed now to the proposition propounded in the introduction. *What method do we possess for demonstrating in excised portions of tissue whether the leprosy bacilli are normal or degenerated by age and treatment.*

As regards the changes which the granules and coccothrix undergo from age and as a result of treatment, unfortunately no systematic investigations have been made. So far we know only that individual granules persist after the death of the acid-fast bacilli. Also we know nothing regarding any alteration of the mucoid substance which occurs along with bacilli masses. However for the last ten years we have been systematically studying how the staining properties of the acid-fast bacilli are altered by age and as the result of treatment.

In all cases the alteration of the staining properties of the acid-fast bacilli is indicated by a diminution of the acid fastness. This can be demonstrated by the ordinary Ziehl stain. Alongside many deeply stained bacilli one recognises feebly staining ones in varying numbers both amongst those lying separate and amongst those in the Gloea. The number of feebly stained acid-fast bacilli can be increased in comparable sections of the same tissue, *e.g.*, in a particular leprous nodule, by weakening the decolorising agent, *e.g.*, instead of 30 per cent. HNO_3, $10\frac{1}{2}$ per cent. or 1 per cent. is used, or the staining is increased, *e.g.*, before staining the section is dried on the slide or stained for 24-28 hours. In this way more well stained bacilli are obtained since many feebly acid-fast bacilli retain the stain more or less. On the contrary the majority of the bacilli with feeble staining properties disappear if one (according to

[1] A. Lutz, Zur Morphologie des microorganisms der lepra. Dermatologisehe Studien 1. Heft 1886 Scop. Voss. Hamburg.

[2] Unna Die feiner struktur des leprabacillus Monatsh. f. prakt. Dermat 1886, Bd. 5, pg. 404.

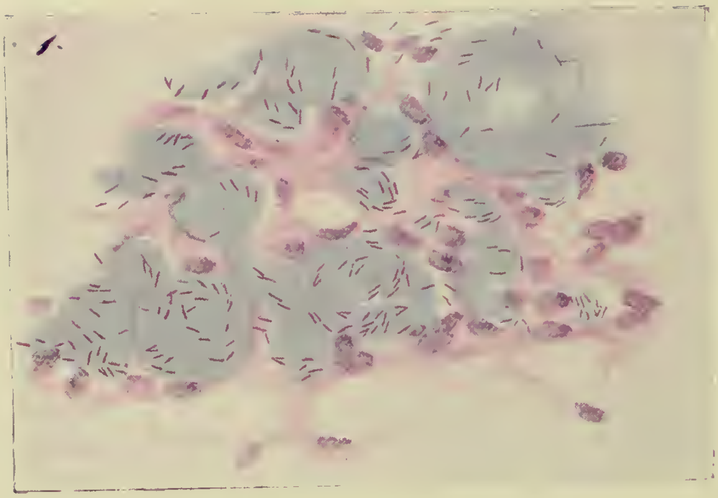
[3] A. Spiegel, Zur differential diagnose von lepra und Tuberkelbacillen Monatsh f. prakt. Dermat.

[4] H. Much, Uber die granuläre nach Ziehl nicht farbbare Form des Tubereulose virus. Beitrage Zur klinik der Tuberculose. Stobery ver lag Wurzburg, Bd. 8, pg. 85.

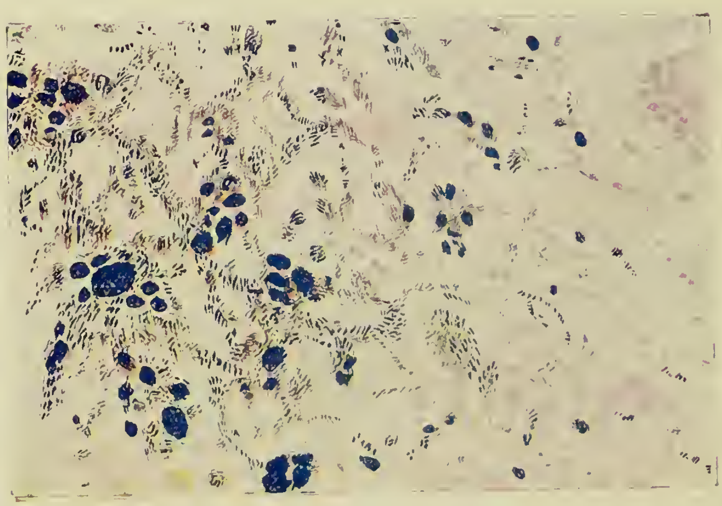
[5] *Unna.* Die Zusamensetzung des leprabacillen schleims. Monatshefte f. prakt Dermat. 1898, Bd. 26, pg. 17.

[6] *Unna.* Uber die Pathologie und Therapie der lepra. Monatsh f. prakt. Dermat. 1906 Bd. 42, pg. 603.

DOUBLE STAIN FOR LEPRA BACILLUS.



Fuchsin-Methylene Blue Method.



Victoria Blue-Safranin Method.

Gabbet-Ernst) adds to the acid a basic stain (*e.g.*, Methylene blue) or attempts to bring out the nucleus or plasma cells by a basic counter-staining of the tissue. An accurate comparison between the results of staining of an untreated and treated leproma can only be made under the following conditions :—*by employing the strongest possible stain and using this in precisely the same way for all the sections.* The comparison is then between the amount of the deep and faintly staining bacilli.

In this method there are two sources of error, objective and subjective. The former on account of the fact that the slight difference in time (the period during which the sections remain in $H NO_3$) may occasion variations in the intensity of the stain. This is scarcely to be avoided, since in practice one stains several sections at the same time which can only be taken out successively from the $H NO_3$. On the other hand from the subjective point of view it is not at all easy to estimate the number of the feebly staining bacilli, whilst it is much easier to count the number of deeply stained bacilli. One will, therefore, have the tendency to underestimate the number of faintly staining bacilli.

On these grounds I have for a long time endeavoured to find a method of staining which will permit of bacilli with feeble staining affinities taking the stain deeply—naturally this is done by counterstaining—*in other words a double stain for the simultaneous staining of normal and of degenerated bacilli.*

With such a double stain it is possible, in the first place, to demonstrate with certainty all bacilli including those with feeble staining affinities and, in the second place, *it has the great subjective advantage that at one glance the number of both kinds of bacilli can be seen and counted.*

At one glance an accurate estimate of the occurrence of diminution of active bacilli is gained, and, if treatment had previously been undertaken, on the effect of the treatment.

In the year 1898 I published the first method of double staining.[7] It consists of the fixation of living tissue by a very weak 1 per mille $H NO_3$ or $H_2 S O_4$ solution. The fresh skin is cut as small as possible, it is placed in this solution for 2 hours, then hardened in alcohol, embedded in celloidin and cut. Before staining the sections are freed from celloidin.

Several sections, about six, are stained at once, then placed on a slide, moderately dried with filter paper. The staining process in these dried sections proceeds more rapidly and intensively than in the dishes. As stain, Ziehl's Carbol-fuchsine is used. The dried sections are stained with a few drops of the stain as follows :—they are covered with a little piece of filter paper and this is saturated with staining solution. In this way not only will an overflow of the stain be prevented, but only filtered stain will come in contact with the section. This method is much cleaner for the hands of the Histologist ; and the evaporation from the filter paper occurs so slowly that it is not necessary to cover the slides to protect them from evaporation.

The sections which have been stained in this way for 1 hour are placed in dishes of water in which the sections gradually float out. One now places these individual sections for a short time (about ½ minute) in 30 per cent. $H NO_3$ and then in 70 per cent. spirit until no more colour comes out, and then in water.

Now follows the staining of the dead bacilli and those with feeble staining affinities.—They are placed for ½ hour in a dish containing Polychrome methylene blue solution. In the sections washed in water, in addition to these dead bacilli, the nuclei, protoplasm and Collogen are stained blue. The latter substance must be freed from Methylene blue by staining for ½ hour in 1 per cent. (*non-acid*) Orcein solution followed by washing in absolute alcohol and water. By this means, certainly, the nuclei and plasma cells will be somewhat decolorised, but without rendering them unrecognisable. The clearness of the picture is increased by it. The moist section is now thoroughly dried on the slide by filter paper and then decolorised with aniline oil 1 per cent. HNO_3 until it shows a pure orcein tint. After washing first with aniline oil and Xylol, it is then embedded in hard Canada balsam, which has been freed from Etherial oils by boiling with chloroform and then liqnified by heating. Fig. 1 is taken from a leprous nodule of the skin at a point on the boundary between the cutis and subcutis. It is distinguished by massive formation of the Gloea. This Gloea partly in the form of small oval bodies and partly in the form of enormously distended large round bodies is composed almost entirely of dead bacilli stained blue and the lymph spaces are expanded into a system of spherical cavities. The blue mucoid degenerated masses enclose only a few normal red stained bacilli.

One sees that the largest masses, which formerly were regarded by most authors as degenerated protoplasm containing bacilli, by this double stain resolve themselves into the bodies of dead bacilli. These mucoid degenerated bacilli masses fill up a great part of the spaces of the lymph system, and incapsule the well stained active bacilli as well as the nuclei of degenerated cells. The untenable theory of a specific degenerated and vacuolated " lepra cell " " leprazelle " is chiefly due to presence of the above having been overlooked.

In the case of the natural cultures of the leprosy bacillus in the human skin, I succeeded in showing formerly (1898) by a double stain that the masses, which were unstainable by Ziehl, in the older cultures resolved themselves into masses of bacilli, which, although not acid fast, were well preserved. Dalbanoo (1905)[8] determined the same in the bulky bacillary mucoid substance of Psittacosis. In the same year I was fortunate in discovering a second double stain.

Victoria-blue-safranine Method, by which the active bacilli appeared in strong colour contrast to the dead ones, namely, a dark blue against Golden Yellow (Fig. 2). I demonstrated preparations of this kind for the first time at the Congress on Pathology and Therapy at

[7] *Unna.* Die Zusamensetzung des leprabacillen schleims. Monatsh f. prakt. Dermat. 1898, Bd. pg. 26, 17.

[8] *Delbanoo*—Die Zusamensetzung des Tuberkelbacillen Schleimes Zur anatomie der Papageien tuberkulose Monatsh. f. prakt. Dermat. 1905, Bd. 41, pg. 363.

Lisbon in 1906.[9] This staining method is based on exactly the same principles of preliminary treatment of the fresh tissue with weak HNO_3. The primary staining of the normal bacilli is produced in this case by Victoria blue, the secondary staining of the dead bacilli with safranine. The dead bacilli stain distinctly. Although at first overstained by Victoria blue they do not retain it when treated with HNO_3. *They do not stain* red with safranine but metachromatic, *viz.*, Golden Yellow, and in this way there is a very fine and sharp contrast between the blue and yellow bacilli.

The details of the procedure are :—

The fresh portions of the leproma are treated, as in the first method; they are fixed in ·1% solution of HNO_3 (or H_2SO_4) dehydrated in alcohol and embedded in celloidin. The sections are placed in a 1 per cent. solution of Victoria blue in carbolic water for 12 hours. The carbolic solution can with advantage be replaced by "Thymen Wasser" which is prepared by shaking a few drops of Thymen (Schimmel & Co., Leipzig) in distilled water and filtering. The sections after washing in water are decolorised with alcohol and brought through water into safranine solution. The latter I have recently prepared with Thymen Wasser and find that a ½ per cent. safranine solution is sufficient. The sections remain in this solution 10 minutes, they are then washed in water, placed for a few seconds in 30 per cent. HNO_3 and decolorised in alcohol. They are then placed in fresh alcohol, oil and boiled balsam.

This beautiful Victoria blue safranine method of double staining for leprosy was very complicated 2 years ago. Formerly I only obtained good preparations by introducing decolorisation with HNO_3 and orcein between the Victoria blue and safranine staining. Then the Golden Yellow colour of the metachromatic safranine was only successful when the 10 per cent. HNO_3 used for the final decolorisation was replaced by a ½ per cent. picric acid solution. This complication of the method was gradually got over. It appears to me, however, not excluded that in the simplification of the method an alteration of safranine (Marke)[10] plays a part. The final experiments are not yet concluded, and therefore I give it as an appendix to my earlier Victoria blue safranine method in order that leprosy investigators who possess other safranine, Marke, may be in a position to investigate. It is also recommended that the period in the safranine stain be varied (from 5 minutes to ½ hour) until the optimum contrast staining for the particular safranine is ascertained.

If with this method a series of untreated lepromas are examined a very peculiar picture is obtained, blue and yellow bacilli are found everywhere, a variegated mixture, without any regularity. In certain lepromas only a few yellow bacilli are mixed with the blue bacilli, in others there are as many yellow as blue bacilli and between them every stage of transition. There is no special arrangement. In every piece of tissue one finds the two kinds mixed together.

[9] Monatsh f prakt. Dermat 1906, Bd. 42., pg. 603.
[10] At the present time I use Marke Safranine, W. O.

It is necessary next to determine that the bacilli which take on the yellow stain are really dead. This is done by a comparison of sections of the same nodules stained by the double and single stain. The yellow stained bacilli appear in the position of the unstained mucoid masses and the double stained preparations contain generally many more bacilli than the single stained preparation. The view that the yellow bacilli are dead is supported by their being specially numerous inside the Gloea, where the masses of dead bacilli were first discovered. Further by the fact that in clinically old lepromas the number of the yellow bacilli is always much greater than in the clinically early, although a few yellow bacilli are found, also, in quite early lepromas. Because normally the yellow and blue bacilli are mixed quite *irregularly* and there is no "normal" for the number of yellow bacilli untreated cases, so it would appear at first sight impossible to determine the effect of treatment in transforming the blue into the yellow bacilli in a particular preparation.

Fortunately, however, we have certain data by which we can recognise the artificial influence on the leproma and the strength of this.

In untreated lepromas it never occurs that all the bacilli are yellow and also they are never *regularly* arranged in zones. If we find after certain caustics, *e.g.*, Potash, that all the bacilli, or at least those in particular zones, are yellow, we cannot but ascribe it to the drug.

Summary of the Method of double staining of living and dead leprosy bacilli in the tissue.

Fuchsine-Methylene-blue Method.	Victoria blue-safranine method.	Older form of the Victoria-blue-safranine Method.
Fixation of fresh skin in HNO_3, 1 per cent., 2 hours.	Fixation of fresh skin in HNO_3, 1—2 hours.	Fixation of fresh skin in HNO_3, 1 per cent., 2 hours.
Harden in Alcohol abs. and embed in Celloidin.	Harden in Alcohol abs. and embed in celloidin.	Harden in Alcohol abs. and embed in celloidin.
Thickness of section 10-15. μ.	Thickness of section 10-15. μ.	Thickness of section 10-15 μ.
1. CarbolFuchsine on slide, 1 hour.	1. Thymen-Victoria-blue, 12 hours.	1. Carbol-Victoria-blue, 12 hours.
2. Water.	2. Water.	2. Water.
3. HNO_3, 30 per cent., a few seconds.	3. Alcohol till no stain comes out.	3. HNO_3, 10 per cent., ½ minute.
4. Alcohol.		
5. Polychrome Methylene-blue solution ½ hour.	4. Water.	4. Alcohol until no more colour comes out.
6. Water.		
7. Orcein solution, 1 per cent., ½ hour.	5. Thymen-safranine, ½ per cent.	5. Orcein solution, 1 per cent., 5 minutes.
8. Alcohol.		6. Alcohol.
9. Water, then dry section on slide with Filter paper.	6. Water.	7. Water.
		8. Safranine solution, 1 per cent.
10. Aniline oil HNO_3 1 per cent. decolorise.	7. HNO_3, 30 per cent. a few seconds.	9. Water.
		10. HNO_3, 10 per cent, Picric acid, ½ per cent., ½ minute.
11. Aniline oil, Xylol Balsam.	8 Alcohol. Bergamot oil, Balsam.	
		11. Alcohol, oil, Balsam.

Also in certain parts the bacilli are regularly arranged, *e.g.*, the bacilli clumps which are situated inside the endothelium of the capillaries of untreated lepromas are always blue, even when those in the surrounding tissue are all yellow. This means either that the bacilli that come in contact with the blood are specially well preserved or the dead bacilli may be washed out of this site. If after a particular treatment the bacilli of the capillaries become yellow they must have been artificially killed.

In view of this fact I found a marked transformation of the blue bacilli into yellow bacilli by the use of external application of Heat, Potash, and of the Phenols, Carbolic acid and Pyrogallol.

A quite peculiar action occurs with the caustic acids. At the point where the caustic has been applied to the cutis, even when it has acted strongly, the bacilli are found to retain the blue stain. We cannot determine at once, in view of the action of Potash and Phenol caustics, whether these bacilli are normal or dead. The strong acids fix or precipitate ('fallen') apparently the albuminous components of bacilli with which the Victoria blue combine.

However at places in the section round a central "caustic" area, there is an inflammatory œdematous "*Caustic*" space with markedly dilated vessels; *there* the bacilli are all yellow and many of them have been washed out. Here apparently the caustic action of the acid has been compensated by the alkali of the blood and lymph and destruction is shown by the bacilli taking the yellow stain. This is specially well seen in the cauterisation with H_2SO_4. In the process of destruction of the bacilli the caustic acids appear only to fix the bacilli and then complete destruction takes place secondarily by inflammatory œdema. According to my observations HNO_3 is the strongest acid.

These experiments with double staining commend themselves for further study. They promise to give valuable results on the relation of the bacilli to drugs.

THE NASTIN B. TREATMENT OF LEPROSY.

By Professor DEYCKE PASCHA.

Owing to a scientific tour to British Guiana, extending over several months, I was unfortunately prevented from personally bringing to the notice of medical men in India a method of treatment of leprosy, which, in my opinion, constitutes a real therapeutic advance. Instead of doing so personally, I must be content to introduce to you by an illustrated address the outline of the scientific basis, the value and significance, the results and the limitations of the treatment of leprosy, elaborated by me in the course of researches extending over many years.

The starting point of the investigations, undertaken by me in collaboration with my Turkish Assistant, Dr. Reschad Bey, was the discovery and growing in pure culture of a peculiar, hitherto unknown, micro-organism (called by me Streptothrix leproides) which we succeeded in isolating repeatedly from a severe case of tubercular leprosy.

Much has been said and written about my having identified this acid-proof bacterium with the genuine exciter of leprosy. It goes without saying that this never has been the case. On the contrary, I have always from the outset accentuated the fact of its *not being identical* with Hansen's bacillus. The possibility, however, of there existing certain generic relations between the two species of bacteria has often been thought of by me at that time and later on, and I have expressed myself to that effect. In fact, it is to this hypothesis entertained by me at that time, to which I am indebted for the discovery of what I deem to be of lasting value for the combating of leprosy. Nowadays, it is true, this hypothesis is only of a historical interest for me and I unhesitatingly say that the existence of generic relations between the genuine leprosy-bacillus and the streptothrix leproides cannot be proved; in fact, on the basis of recent comparative chemical and biological researches regarding endobacillary albuminoid substances of the streptothricheæ and of the tubercle bacilli which in the system certainly come near to the leprosy-bacilli, I do not even consider such relations to be probable.

One point only, and it is the most important one, remains, namely, the fact that streptothrix leproides contains a substance which is capable of exerting an active influence on the leprosy-process or the leprosy-exciter, and that in all probability—in fact it cannot be otherwise, if our views, held hitherto, are correct—this same substance is bound to be present also in the leprosy-bacillus and it is certainly contained in the tubercle-bacillus. It is this substance, its properties and effects which form the subject of the following remarks:—

In order to prove the existence of any relations between the streptothrix leproides and the genuine leprosy-exciters, I had, at the time, made inoculation experiments with living culture material, in the first place on that patient from whom the culture was derived; later on, however, on a good number of other sufferers from leprosy. The surprising result of these experiments was a striking improvement in respect of general health and of the leprous phenomena; it was most pronounced and very remarkable in the first case in which fever, which had been existing for months, disappeared, and the symptoms, some of them very severe, retrogressed in such a manner that after about eight weeks' treatment the patient deemed himself cured and refused to stay in the hospital any longer. But also in the case of other patients the improvement was so remarkable that one could not help becoming impressed with the idea that the culture must contain a substance exerting a favourable influence on the leprous process. With a view of

discovering this active substance, I endeavoured to obtain cultures, in large quantities, of streptothricheæ. I succeeded in doing so with unskimmed milk on the surface of which there form in a few weeks massy culture membranes of a splendid orange-red tint, which can easily be removed *in toto*. The membranes collected then were subjected to systematic chemical treatment and the thus obtained fractions were tried regarding their efficacy by experiments, extending over months, on leprous persons. Enzyme-like or other substances, soluble in water, could be excluded, also albuminous substances; it was found, however, that the active principle must be contained in ether extract. Ultimately I succeeded, by a method of my own, in isolating from the ether-extract (which proved to be a very complex mixture of genuine fat and so-called lipoid substances) a well-defined substance which, clinically beyond doubt, had to be regarded as carrier and, indeed, as the *sole carrier*, of the curative effects. This peculiar fatty substance, which I called *Nastin*, is a genuine neutral fat, *i.e.*, the glycerine-ester of a high-molecular fatty acid, and as such, it readily and completely saponifies. It crystallises in the form of beautiful acicular star, and sheaf-like crystals. It melts at a temperature of 48 to 52°C and, when cooling, forms a hard wax-like mass. Interesting is the fact that it is only the *unchanged* Nastin molecule which is effective, the fatty acids, obtained through saponifying Nastin, as also their soaps, have lost every therapeutic property.

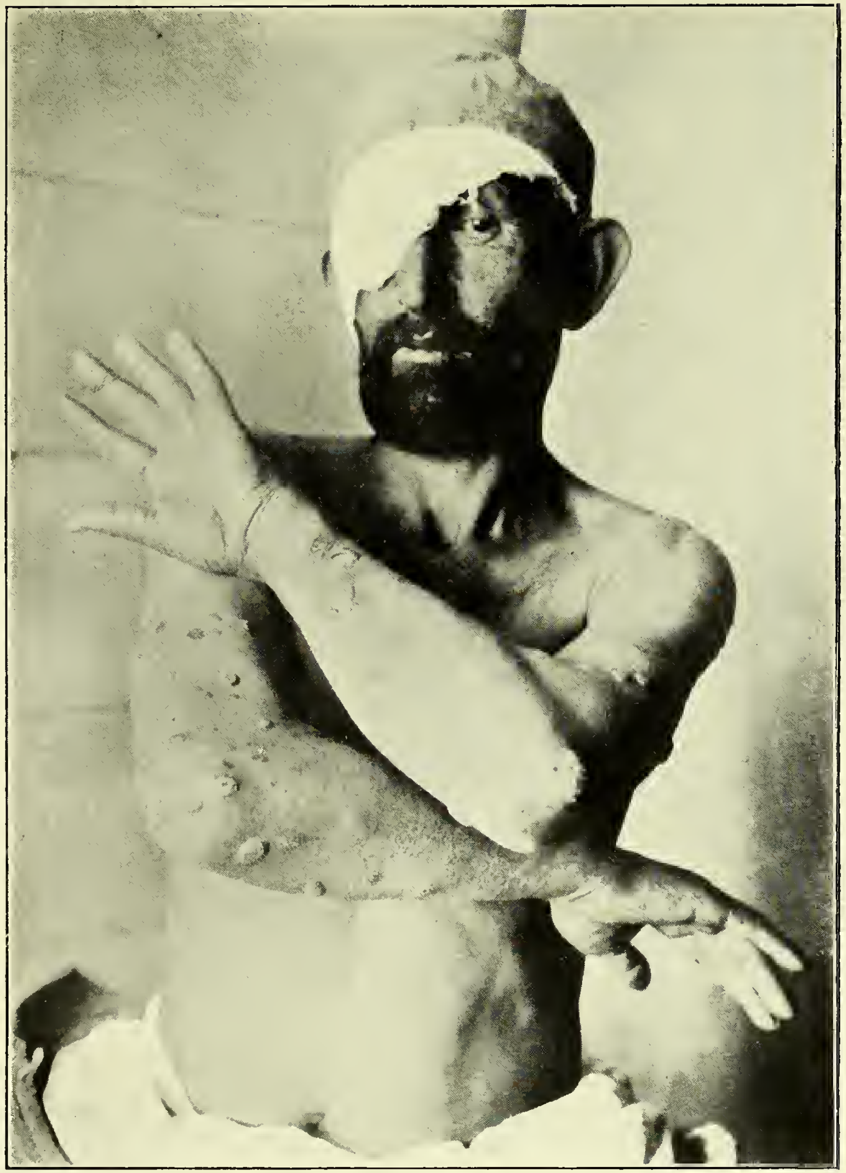
Injections of pure Nastin in oily solution, which we employed at the outset, give rise in the case of leprous patients to reactions in the leprous tissue, consisting in inflammatory swelling, suppuration and necrosis. Clinically the greatest individual differences are to be observed; on the one hand there are patients who appear to be almost completely refractory and do not show any external phenomena of reaction even after injections have been given for weeks and months; on the other hand, in the case of some patients the application of but a few injections of Nastin is followed by dangerous, general and local reactions; and between these two extremes all possible graduations take place.

The reactions in the leprous tissue are always accompanied by a pronounced bacteriolysis of the leprosy-bacilli which, as may easily be observed by microscopic examination, is heralded in by the removal of fat from the bacilli, that is, if one makes use of *Ziehl's* staining method, by loss of this specific property as to staining. Strictly speaking the process of bacteriolysis takes place in two forms. Either there becomes perceptible in the case of Ziehl's staining a gradual diffuse fading of the red colouration until the bacilli-nuclei appear *in toto* quite unstained or slightly tinted in the blue contrast colour and ultimately are completely dissolved—extinguished, so to say, in the picture. Or—and this seems, to me, to be the more frequent and really typical course—there appear at first stainless gaps in the intensely red-stained bacilli-nuclei, also the well-known segmented forms reminding one of cocci chains; then the cohesion between the—as yet—red, *i.e.*, still fat-containing, parts of the bacilli is lost, the remaining fragments and granules precipitating together and forming more or less voluminous masses which, at first still distinctly stained, gradually also lose the red pigment and ultimately disappear altogether. Here I would just mention that the bacteriolytical processes in leprosy-bacilli run a course very similar to the analogous processes in tubercle bacilli, and that both these species of bacteria also correspond in that, at a certain stage of retrogression, there can only still be stained, and that solely according to Gram's method as modified by Much, the most minute granules which, in the case of tuberculosis, have been proved by Much to be able under certain circumstances to again grow into acid-proof rodlets. On the other hand it seems, as far as can be deduced from clinical and microscopic observations, that, in the case of leprosy, the initial removal of fat from leprosy-bacilli entails their being doomed, *i.e.*, once they are deprived of fat there ensues further dissolution and total destruction.

My researches aiming at discovering a theoretical explanation of the mechanism of bacteriolysis led to further knowledge which proved useful also in practical respects.

Seeing that in the course of Nastin-reactions a pronounced participation of leucocytes always occurred, I first thought that the injection of Nastin would promote the formation of fat-splitting ferments in the leucocytary cells. Lipase from pancreas and castor-oil seeds, it is true, did not furnish evidence in vitro of an effect in the fat removing sense, on other acid-proof bacteria. So I again had recourse to experiments. By means of intravenous injections of hetol (sodium cinnamate) we were able to produce in leprous persons pronounced general leucocytosis which, however, did not exert the slightest influence on the specific process. If, however, at the height of leucocytosis Nastin was injected, there always ensued reactions which generally set in in a turbulent manner, and ran an energetic course even in the case of patients who otherwise had been refractory to Nastin.

These very remarkable clinical observations induced me to inquire more searchingly what becomes of cinnamic acid in the organism. Cinnamic acid ($C_8H_5-CH-CH-COOH$) being, throughout, excreted in the form of hippuric acid (benzoyl-glycocoll) it is transformed in the tissues into benzoic acid through oxidation. This substance, however, proved ineffective in vivo, i.e., it did not activate Nastin in the slightest. But also in experiments, in vitro, which we made with tubercle bacilli, no trace of a fat-removing property of benzoic acid regarding these bacilli was discovered. On the other hand, benzaldehyde (C_6H_5-COH), the intermediary product of oxidation of cinnamic acid, activated Nastin in vivo most distinctly and, in vitro, we found, for the first time, that benzaldehyde is a substance which—although at a high temperature only—is capable of depriving tubercle-bacilli of fat so completely that they lose their "acid-proofness." Seeing that benzyl-alcohol ($C_6H_5-CH_2-OH$) which directly has no connection with cinnamic acid, but is, likewise, through oxidation, transformed into benzoic acid, displays in vivo and in vitro the same properties as benzaldehyde does, one was enabled from all this to draw the conclusion that it was the benzoyl group C_6H_5-CO,



Case IV *a*.

Case IV *b*.

appearing at the moment of splitting up, which could not but be the active principle proper. And, indeed, it was ascertained that the substance which most readily splits off the said group of atoms, *viz.*, Benzoyl-chloride (C_6H_5—CO—Cl), in the cold deprives tubercle bacilli of fat in a few minutes and does so at once when heated. This fact is all the more remarkable as, with the usual agents for extracting fat, such as ether, chloroform, benzine, xylol, etc. one hardly ever—even if their action is continued for weeks and months—succeeds in depriving tubercle-bacilli of fat to such an extent that they lose their "acid-proofness."

On the strength of established facts of such importance we deemed ourselves justified in making trials with combinations of Nastin and Benzoyl-chloride, on leprous persons, having, of course, satisfied ourselves previously in the case of animals, of the innocuousness of this—chemically so active—substance.

The very first trials made it plain that in the new combination Nastin displayed a very important and, above all, a far more constant activity than in the original (pure) form. Nevertheless the difficulties which stood in the way of introducing our treatment into medical practice, were not done away with yet. For so long as we adhered to the—at first—comparatively high doses of Nastin, we were confronted by more or less violent reactions, whose incalculable intensity was fraught with too many dangers to allow of our considering our method as suitable for general use.

This state of affairs did not alter until, in the further course of our experiments, we decreased the dosage of Nastin itself. It became manifest, namely, that in the combined, so-called Benzoyl-Nastin-solutions the reactivity was greatly influenced by and dependent on the *relative* proportion between Nastin and Benzoyl-chloride. In the event of Nastin being present relatively in excess, *i.e.*, if the amount of Nastin exceeded a certain measure in proportion to Benzoyl-chloride, there ensued reactions; and *vice versa*, *i.e.*, if Benzoyl-chloride was relatively in excess, the reactions were absent without the therapeutic efficacy being eliminated in the case of suitable dosage. On the contrary, well-adjusted solutions—more especially if employed for a considerable period, gave evidence in every respect, of satisfactory therapeutic efficacy which also was recognised microscopically in the influencing of the leprosy-bacilli in the fat removing sense and in bacteriolysis—and all this without local or general reactions having taken place. In one word, under the influence of such solutions the whole process ran its course, by slow degrees but steadily, less obvious for the medical attendant, but without any danger for the patient. A solution of this kind you have, for example, in the so-called Nastin-B. which has been placed on the market. This solution, termed classical by me, contains Nastin in the proportion of 1·40 of Benzoyl-chloride, will *not cause any* reaction and does not cause any unless exceptional conditions obtain. Nevertheless it is thoroughly effective in therapeutic respects and produces, in my opinion, *better* results in the long run than any reactive solution. I would expressly accentuate this point because again and again there arises the mistaken idea that, without visible reaction, no therapeutic effect was obtainable.

With regard to the before mentioned exceptional conditions in which even the classical solution may give rise to reactions, I would just say that, irrespective of too frequent use, it is certain cases of ophthalmic and nerve-leprosy which I have in my mind in this connection. For both forms I have introduced into medical practice a specially diluted solution, *viz.*, Nastin B0, whose concentration, I feel sure, is a guarantee for the non-occurrence of any reaction. I am particularly anxious to attain this end, because according to my experiences Nastin-reaction may, under certain circumstances, in consequence of clouding of the refracting media and secondary glaucoma, become more dangerous to the eye and the faculty of vision, than the leprous localisations themselves, and because also in nerve-leprosy, particularly if it is a question of very fresh cases, Nastin injections may be followed by apparently fresh eruptions.

The observations in the case of nerve-leprosy have proved particularly valuable to me in solving the task of ascertaining the proper proportion in which to mix Nastin and Benzoyl-chloride, and they are so interesting that I cannot help briefly referring to them. Before now, when employing unmixed Nastin, I had already frequently found new symptoms to appear in distinct connection with the injections. With highly concentrated Benzoyl-Nastin solutions I was able to constantly produce these peculiar symptoms with absolute certainty. It was a question of phenomena which suddenly sprang up within a few hours and whose appearance and character such as pemphigoid blisters and ulcerations, respectively, may best be compared to scalding of the second and third degree. From analogy of the Nastin-reactions on leprous skin and mucous membranes, which take place under our eyes, I think I may draw the conclusion that these eruptions owe their origin to an inflammatory, possibly leucocytary reaction within a leprous nerve-centre. This reaction then transmits itself in the form of some alteration of condition to the still preserved nerve filaments connected with the periphery and gives rise at the periphery to the aforesaid *purely trophic disorders.*

Interesting as these occurrences appear to be regarding the theory anent the origin of many symptoms of anæsthetising leprosy, they are little desirable in therapeutic respects. We were, therefore, pleased all the more, when we ascertained that weak Benzoyl-Nastin-solutions were not followed by such eruptions, but that, on the contrary, they led occasionally within a surprisingly short time to a remarkable improvement of the nervous functional disturbances and that to an extent which I should not have thought possible formerly. Just to give a clinical example;—A patient who, irrespective of mutilations on hands and feet (which may give an idea of the severe nature of the case) was afflicted with such total anæsthesia on arms and legs that one day he contracted severe spontaneous scaldings; after a few injections of Nastin B1 he felt again completely normal, even as regards all properties of sensibility.

If, on the strength of such unassailable clinical facts, I consider the curative efficaciousness—ensuing, as it does, without any reaction—of the classic Benzoyl-Nastin-solutions, if, furthermore, I take into account that Benzoylchloride *by itself without* Nastin—as has been demonstrated by numerous experiments—is ineffective in the specific sense, I deem myself justified in adhering to a theory which at the time I expressed in the following way :—

In the classic Benzoyl-Nastin-solutions *Benzoyl* is the *active* principle proper which acts direct on the leprosy-exciters but which, in order to reach the bacilli at all, and avoid being used up and becoming ineffective during transit, requires, so to say, the guidance of the otherwise *passive Nastin.* Nastin charges itself in the oily solution with Benzoyl—not,however,in the form of chemical union, but rather in a state of simple solution—protects it against being prematurely and uselessly used up, carries it to the leprosy-bacilli to which, owing to its near chemical and physical relation, it attaches itself, and then Benzoyl can fully display its antibacterial action in the fat-removing sense.

The result of my researches may be summed up in the short sentence :—Benzoyl-Nastin is an agent which directly acts on leprosy-bacilli. This sentence expresses—in comparison with other therapeutic efforts—the advantages and progress of the Nastin-treatment of leprosy ; on the other hand, however, it clearly points out the limitations of the treatment.

Let us just imagine for a moment how a chronic infectious disease, such as leprosy is, arises. We have to take into account two factors, which (and this is the main point) are *living* factors, *viz.*, the specific exciter without which the disease, of course, is unimaginable, and the human organism which actively reacts on the invading parasites, and which produces the pathological-anatomical formations which we recognise as symptoms of disease. It will depend, however, wholly on the nature and characteristics of these formations whether the symptoms disappear upon the destruction of the exciters. If it is a question of delicate, transient formations as is generally the case in the early stage of syphilis, the disappearance of the exciter will approximately keep pace with the doing away of the symptoms. If, however, the disease has given rise to tumour-like formations or to extensive massy infiltrations, the coinciding of both phenomena will be missed even, were one to succeed by means of the specific treatment, in destroying *all at once all* the parasites, irrespective of the fact that this assumption does not hold good even in that chronic disease, against which our medical armamentarium affords, comparatively speaking, the most efficacious therapeutic remedies, namely, syphilis. Every medical man is aware that syphilis is never thoroughly done away with after a single, be it ever so energetic, antisyphilitic cure ; there is invariably needed an intense and expert treatment in order really to get rid of constitutional syphilis. And, withal, the spirochætes of syphilis are parasites which can hardly be numbered amongst those possessed of the greatest resisting powers, and in mercury we possess a remedy whose direct antiparasitic efficacy has but recently been confirmed anew by Neisser's experimental researches.

If one ponders over such ideas—and why should that which applies already to syphilis, not hold good all the more in the case of tuberculosis and leprosy with their exciters of disease which are possessed of such enormous resisting powers ?—then I say, one will not wonder at Nastin being not a magic remedy by means of which persons, afflicted with advanced leprosy, can be cured and become normal after a few weeks or months. However, if the Nastin-therapy of leprosy is resorted to without exaggerated expectations, I think the results will be satisfactory. For if on the strength of my own experience I may be allowed to give an opinion on the efficiency of this method of treatment, it is to the following effect :—

In the majority of cases—irrespective, of course, of the most severe and hopelessly advanced forms—it will be possible to arrest the leprous process ; in many cases there will be obtained a distinct improvement which is evidenced in a particularly pronounced manner by increase in strength and general health, and unmistakeable retrogression of the leprous symptoms. Whereas on the one hand there are lepromæ—and these, in most cases, are clearly circumscribed tubercular formations—which persistently resist the treatment ; there are seen, on the other hand, leprous forms of exanthema, which are acted upon and done away with by Nastin not less promptly than are syphilitic efflorescences by mercury; and frequently extensive, even massy, infiltrations are caused to disappear with surprising rapidity. There are graduations between the extremes ; generally, however, medical attendants and patients will be wise in being prepared for a long-continued, I might say, chronic, treatment ; in practice I would recommend to give it the character of an intermittent treatment, continued for years, on the lines of antisyphilitic cures.

It goes without saying that nothing bars the way of combining the Nastin-therapy, representing, as it does, a pronounced *general treatment* with *local* treatment of single, more especially persistent, symptoms of leprosy. Although for obvious reasons I have resorted to other therapeutic measures but seldom and as an exception, still I have learned from such a case that under certain circumstances one succeeds, by means of combined internal and surgical treatment, in completely freeing leprous persons from their symptoms in a surprisingly short time. In the case in question it took only two months.

Taking all in all I think that every medical man who, without prejudice resorts earnestly and perseveringly to the Nastin-therapy, will become convinced that my method of treatment constitutes a real advance in the treatment and combating of this terrible disease.

In conclusion a number of illustrations may demonstrate what is obtainable in the case of leprous persons by means of the Nastin-therapy.

THE NASTIN B. TREATMENT OF LEPROSY.

By Captain T. S. B. WILLIAMS, I.M.S.

Professor Deycke having given all the details regarding the theory of the treatment it only remains for me to give the results which I have so far obtained with his treatment. I commenced treatment on the 18th June 1908 on three cases; on the 22nd July 1908 on a fourth case; and on 24th December 1908 on a fifth case. The details of these cases are given below :—

The treatment being at present relatively expensive, and of long duration, I determined to confine myself at first to four cases whom I could keep under continual observation. Later I have taken on a fifth case. Each case has been confirmed microscopically.

Case I.—Hossein, age 32.

I.—*Condition on 17th June 1908 at commencement of treatment.*—He says that he has been suffering from this disease for about four years. He has the following obvious leprous lesions :—(1) thickening of both eye-brow regions with partial falling out of the hairs, (2) small lepromata on both ears, (3) seven small lepromata on chin region, of which one is ½ inch in diameter and raised ¼ inch from surrounding surface, (4) on outer surface lower right forearm four small lepromata, (5) on outer surface lower left forearm three lepromata, (6) small lepromata on back of neck, (7) front of trunk shows a very definite rythematous condition of skin, with marked diffuse infiltration of skin, (8) back of trunk, over region between inferior angle of scapula and iliac crests, shows many small lepromata, together with diffuse erythematous thickening of skin, (9) right buttock, eight lepromata of varying sizes, (10) left buttock, two lepromata, (11) front of both thighs show a few small lepromata, (12) anæsthesia—

(*a*) The anterior two-thirds of both legs, from two inches below tubercles of tibiæ down to two inches above malleoli is anæsthetic, except to very deep pressure. Below indicated level all parts anæsthetic, even to deep pressure.

(*b*) Dorsum of hands shows delayed sensation.

(*c*) Skin of anæsthetic parts harsh, and some areas quite leathery. It does not sweat.

General Condition.—He is in a very poor state as regards his general health. He is weak and anæmic. Very slight physical exertion tires him. His hands and legs feel heavy, and as if he had lost control over them. He has no desire for sexual intercourse. Patient is a married man with a family, none of whom are suffering from this disease. The leprosy bacillus was found in great numbers wherever examination was made, found also in the nose.

II.—*Treatment* was commenced on 18th June 1908, and up to 8th January he has received :—

(*a*) Twenty-two injections of Nastin B_1 (1 c.c. each).

(*b*) Eighteen injections of Nastin B_2 (1 c.c. each).

III.—*Present Condition on January 8th,* 1909.—The obvious lesions have been affected as follows : (1) thickening of eyebrow regions gone, but hairs have not grown again, as thickly as I imagined they would; (2) small lepromata on both ears have disappeared; (3) lepromata on chin region have disappeared : the large one is now represented by a scar, and whereas formerly a smear from this showed crowds of bacilli, to-day I failed to find a bacillus; (4) lepromata on outer surface lower right forearm gone; (5) lepromata on outer surface lower left forearm also gone; (6) lepromata on back of neck disappeared; (7) front of trunk normal; (8) back of trunk shows very marked improvement—three very small retroceding lepromata remain, with a certain amount of infiltration around them, compared with 18th June 1908, however, back of trunk approaches normal; (9) right buttock, lepromata represented by pigmented scars; (10) left buttock, lepromata represented by pigmented scars; (11) front of thighs normal; (12) anæsthesia :

(*a*) with exception of small area over lower part of inner surface of right tibia, sensation as regards common sensation is normal. He cannot still distinguish accurately between sharp and blunt; hot or cold. Over area mentioned on inner surface of right tibia, sensation has returned, but it is somewhat delayed.

(*b*) Dorsum of hands normal.

(*c*) Harsh appearance of skin remains and it does not sweat.

General Condition.—He is now in excellent general health. Says he feels as well as he ever did. Does any reasonable amount of physical work now without feeling tired. Desire for sexual intercourse has returned to normal. His face now has a clean and healthy look, instead of the dirty anæmic look of seven months ago. The large leproma on the chin was selected to check the improvement microscopically. Slides from this are shown in the Pathalogical Exhibition, and they show a gradual diminution in numbers of bacilli, together with loss of acid fastness and marked degeneration. These changes were coincident with clinical improvement. The last slide shown does not contain any leprosy bacilli, and should be compared with the first, taken before treatment.

Case II.—Hassan, aged about 30.

I. *Condition on 17th June 1908 at commencement of treatment.*—He has suffered from tubercular leprosy since 11-12 years. He is very weak and anæmic. He is unable to walk upright, or to stand without the assistance of a big stick. He moves about slowly in a sitting position, helping himself along with his hands. His face is typical, with no eye-brows or moustache. He is altogether a pitiable sight. He is well known here, having been in

the habit of sitting about the outside of the Residency, a huddled up ulcerated mass of humanity, covered with flies.

He has ulcers on (1) face, (2) trunk, (3) posterior both elbows, (4) posterior both forearms, (5) on legs, (6) both testicles enlarged owing to leprous infiltration, and over right testicle there is a very large ulcer, with the testicle forming the base of the ulcer. Both mammary glands are much enlarged owing to disorganization of testicles. His hands are swollen and nodular, due to lesions of the metacarpals.

II. *Treatment* was commenced on 18th June 1908 and up to 8th January he has received—

(*a*) Twenty-eight injections of Nastin B_1 (1 c.c. each).
(*b*) Three injections of Nastin B_2 (1 c.c. each).

III.—*Present Condition on 8th January* 1909.—He is now able to walk about in an upright position, without the aid of any stick, and to go any reasonable distance. Every ulcer, except that on testicle, is healed, and, where formerly crowds of bacilli were found in films made from ulcers, films made now by incising the scars show no bacilli. The testicle ulcer had healed by 24th September. About the 27th December, it however broke out again, to about a quarter of its former size. Films made from this ulcer now show that the bacilli are undergoing marked degeneration as evidenced by loss of acid proofness, granulation and counterstaining. To-day, *viz.*, 8th January 1909, it shows every sign of again healing. In my opinion this ulcer is the result of excessive reaction occurring in a small focus which had been covered in prematurely. The swellings of hands are smaller, and movements of fingers are freer.

Altogether this patient shows great improvement. He is in every way fitter and cleaner. His face also shows the same improvement in complexion, already noted in Case I, and if it were not for the absence of eyebrows and moustache, it would not be at all repulsive. Formerly he was not allowed to go into the bazaars, but now he is allowed to do so. He complains very much that, owing to the marked improvements in his condition, he cannot earn as much as formerly at his occupation of professional beggar.

Case III.—Gooloo, leper boy, aged 14.

I.—*Condition on 17th June* 1908 *at commencement of treatment.*—Has had leprosy for last four years. He is fairly generally covered with lepromata. In most cases they are small like a marble, but some are quite large. In front of lower part of right thigh, there are three large ulcers. Also ulcers over both elbows and on outer side of right knee. Face shows incipient leontiasis, with loss of eyebrow hairs. Fingers and toes are thickened due to subcutaneous and probably periosteal infiltration. They present a thick, clumsy appearance. On the inner side of right foot there is an ulcer three inches long by one inch wide. Larynx and whole of buccal mucous membrane extensively affected. Patient can only speak in a hoarse whisper.

Anæsthesia.—Marked anæsthesia on outer halves of both legs and thighs, up to gluteal regions. Inner halves unaffected. Back of hands slightly anæsthetic.

General Condition.—He is in a very weak state. Drags himself along slowly. No life at all in his movements. Not allowed in the bazaar.

II. *Treatment* was commenced on 18th June 1908, and up to 8th January he has received—

(*a*) Six injections Nastin B_0 (1 c.c. each).
(*b*) Nineteen injections Nastin B_1 (1 c.c. each).
(*c*) Fourteen injections Nastin B_2 (1 c.c. each).

On account of laryngeal affection I used for a long time the weakest solution, *viz.*, Nastin B_0. Although there was slow improvement in his general health, and fairly rapid disappearance of anæsthesia, there was not much change in the ulcers and lepromata, until I commenced, in the beginning of December, pushing the treatment, and giving stronger doses. Patients differ very markedly in their reaction to Nastin. Case I was upset by small doses at relatively infrequent intervals. This boy, Case III, however, stood six injections of Nastin B_1 and twelve injections of Nastin B_2 in 29 days, before he showed signs of reaction. When it did come it was severe, the local part of it however being confined quite definitely to leprous tissue. The reaction in parts consisted in a kind of œdema of the lepromata; in other there was definite inflammation of the lepromata, which suppurated and broke down. It is not advisable to push the treatment as far as this. Owing to the slowness of reaction, I overdid it. I have however satisfied myself that the injection can cause a very decided reaction in leprous tissues, situated at a distance from the site of injection. He also suffered from general symptoms, such as fever, pains in the limbs, etc., etc.

III.—*Present Condition on January 8th*, 1909.—At the present moment he is suffering from a severe reaction which prevents him getting about. Taking his condition generally, however, there is very great improvement in his general health. He can, when reaction is not present, walk about absolutely normally. He is very cheerful and lively. He is only 14 years old, and he plays about now, like a normal boy of that age. The ulcer on inner side of right foot is healed; so are ulcers on elbows, and outer side of right knee. Ulcers on right thigh are involved in present reaction. Lepromata have in many cases gone and remainder are obviously disappearing. Anæsthesia has quite gone. Voice is much stronger and buccal lesions show great amelioration. At present moment, he is, as mentioned above, the subject of reaction. He has fever, and an inflammatory reaction in very many lepromata. Many lepromata became inflamed, then suppurated and broke down, leaving flat discharging ulcers. His face shows very great improvement, although there is no indication of returning eyebrow hairs. He tells me that now they allow him to go through the bazaar as far as his brother's house. At first he was very refractory as regards the treatment, but has now realised how it has improved his condition, and is the keenest of all to get his injection.

Case IV.—Ali, aged 30.

I.—*Condition on 22nd July at commencement of Treatment.*—A very distinct leper, with no eyebrows or

moustache. He has no lepromata and no anæsthetic patches. His face however is the seat of a diffuse leathery thickening of the skin. Scars of old ulcers. Little fingers represented by stumps with nails on ends. Large inguinal gland swellings on both sides, probably leprous, together with elephantoid thickening of lower parts of both legs and feet. Over each external malleolus there are chronic ulcers, neither of which contains leprosy bacilli. They are probably due to defective nutrition caused by lymph stasis. Leprosy bacilli found in scrapings from nose.

General Condition.—He is very weak and anæmic. He used to work as a "hamal" (porter), but is now unable to do more than just get about slowly to his various begging pitches.

II.—*Treatment* was commenced on 22nd July 1908, and up to 8th January 1909 he has received—

(*a*) Twenty-two injections Nastin B_1 (1 c.c. each).
(*b*) One injection Nastin B_2 (1 c.c.).

III.—*Present Condition on 8th January* 1909.—There is most marked improvement in his general health, and

CASE V.—*24th December* 1908.

Black = Absolute Anæsthesia.

Shaded = Delayed Sensation.

I hope to show photographs which will show improvement as far as his face is concerned. He is very cheerful and says he feels quite well. He has just lately again taken up his old occupation of a "hamal." This entails heavy work, and is a satisfactory indication of how he feels himself.

CASE V.—HASSAN (Jabri), age 25.

I.—*Condition on 24th December 1908 at commencement of treatment.*—Patient has partial loss of eyebrows with thickening of eyebrow regions. Total loss of moustache. His face is in condition of incipient leontiasis. His main symptoms however are sensory, and affect both arms and legs. The diagram given will show at a glance the areas of complete and partial anæsthesia. The condition is extraordinarily symmetrical.

General Health does not seem to be affected.

II.—Treatment commenced on 24th December, and up to 8th January he has received—

(*a*) Ten injections of Nastin B_0.

III.—Present condition.—At present he is able to feel in all places on arms previously anæsthetic. Also in severally previously anæsthetic areas on legs he can just distinguish when he is being touched.

From the cases, as far as they have gone, it will be seen that there has been a distinct amelioration of the condition. Case I has improved so much, that I consider him as approximating a cure. The improvement might be discussed under the four following heads :—

(1) General health.
(2) Anæsthesia.
(3) Lepromata and ulcers.
(4) Microscopical changes.

(1) *General Health.*—Improvement in this respect has been marked in Cases I, II, III and IV. Deycke emphasizes the improvement in general health, and these cases certainly bear him out.

(2) *Anæsthesia.*—Deycke himself was surprised at the rapidity with which some cases cleared up. In my Case I, sensation had returned over most of the previously anæsthetic area after one month. To common sensation it is now about normal, with exception of area mentioned in record of his case. He is still, however, unable to distinguish really accurately between sharp and blunt, hot or cold. In Case III the anæsthetic area cleared up very rapidly, but I omitted to note the date at which sensation had fully returned. In Case V, after ten injections of Nastin B_0 (1) he can feel light touch in all previously anæsthetic areas of arms and (2) in several places on the previously anæsthetic areas of legs; he can locate the spot, when lightly touched. In arms he can locate the spot where he is being touched, quite rapidly. In the legs, however, there is a distinct pause after he is touched, and then he slowly indicates the area touched. Had not Deycke mentioned the rapidity with which some cases of anæsthesia clear up, I should have hesitated to record this, so far, rapid improvement in Case V. It, however, confirms his statements regarding his own cases. I have really mentioned Case V in this paper, in the hope that after another month's treatment I may be able to record at the Congress further and more distinct progress.

Lepromata and Ulcers.—With the exception of the breaking down of testicle ulcer in Case II, all ulcers have progressed steadily towards cicatrisation. Lepromata have either disappeared or have distinctly diminished in size, in most cases without any evident reaction. Only in Case III, has an acute reaction occurred, and it has been useful in confirming the fact that Nastin is capable of producing reactions confined to the leprous tissue. In Case III, the lepromata not obviously involved in the reaction have markedly diminished in size during the acute stage of reaction in the other lepromata.

Microscopical Changes.—Smears were made regularly from Cases I, II and III. All the changes described by Professor Deycke, were observed, and I hope some of them may be evident in the preparations shown in the Pathological Section.

Cases II, III and IV have been living under the worst possible conditions, and these conditions have remained the same during treatment. In fact, in all cases, nothing was done for the first six months, except to administer Nastin. After six months' treatment, when I felt convinced that the Nastin was really exercising a specific effect, I gave general tonics in addition.

The treatment is, as Deycke himself says, essentially one for institutions, at any rate as far as ignorant patients are concerned. The ordinary out-patient is unlikely to keep up the regular attendance, extending over months, or perhaps years, which the Nastin treatment involves. I believe, however, that we have now a remedy, which, if carefully used, involves no risk to the patient, and which can in most cases arrest the disease. In many cases, especially fresh cases without coarse lesions, the results will approximate to a cure.

Nastin B is supplied in three strengths by Messrs. Kalle and Co. of Biebrich, Germany, *viz.*—

Nastin B_0 ......Very weak.
Nastin B_1 ......Medium.
Nastin B_2 ......Very strong.

It is put up in ampoules containing the Nastin and Benzoyl Chloride dissolved in sterilised olive oil. The olive oil and Benzoyl Chloride remain the same in all three, *viz.*, 1 c. c. olive oil with 2 per cent. of Benzoyl Chloride. The variation occurs only in Nastin, and is as follows :—

Nastin B_0 contains ·02 per cent. Nastin (·0002 gramme).
Nastin B_1 contains ·05 per cent. Nastin (·0005 gramme).
Nastin B_2 contains ·2 per cent. Nastin (·002 gramme).

The illustrations referred to by Professor Deycke will be shown as a separate lantern demonstration.

In conclusion I must cordially thank Professor Deycke for his kindness in sending me a paper to read at the Congress, and for his help in many other ways. My thanks are also due to Captain M. F. White, I.M.S., who carried on the treatment for me during my absence from Bushire on privilege leave.

NOTES ON THE TREATMENT OF LEPROSY BY NASTIN.

By Major THOS. JACKSON, M.B., B.Ch., B.A.O., I.M.S.,

Superintendent, Kagrapeth Leper Asylum, Ahmedabad.

1. Some time ago I applied to the Surgeon-General with the Government of Bombay for means to try Professor Deycke's Nastin in the Kagrapeth Leper Asylum, Ahmedabad. I estimated that to treat 10 patients for 6 months a sum of Rs. 600 would be required. Government was pleased to sanction that amount and on the 14th October I began the treatment of 9 lepers.

2. There are some 60 lepers in the Asylum and I had intended to select some of the severer and some of the milder cases of both sexes, but when I began to select cases I found not one willing to undergo the treatment. They all had a strong objection to hypodermic medication. After explaining matters and assuring them that no inconvenience would be caused, 9 male patients came forward. They were all more or less chronic cases.

3. I append a list of the patients treated, giving their condition before and after 14 weeks' treatment. One injection of 1 c. c. of Nastin B. 1, was given weekly, after the first injection which was $\frac{3}{4}$ c.c. only. By referring to the list it will be seen that considerable improvement is recorded in some of the cases and slight improvement in most of the others. Comparing, now, these new cases with the other lepers in the Asylum there appears to be a decided improvement in the general condition. So far as I can judge clinically of the treatment after 14 weeks' trial, I consider the result encouraging and would recommend a wider adoption of it, as it appears to be the only treatment which offers any hope of amelioration or cure in an otherwise incurable disease.

4. All the patients have, while under treatment, maintained good general health and most of them have increased in weight. There has been no general reaction and little or no local reaction. A few times there was slight local inflammation which subsided quickly.

5. The preparation used was Nastin B. 1, a solution of Nastin in Benzoyl chloride of about 1 in 30, which is the preparation recommended by Deycke for general use. Stronger solutions, he states, cause local and general reactions. The syringe used is the one supplied by the Bacteriological Laboratory, Bombay, for inoculating with antiplague vaccine, a metal syringe with rubber fittings. It is sterilised in vaseline heated to 160 C. I consider this hardier and simpler than the all-glass syringe to be sterilised and always kept in anhydrous ether as recommended by Professor Deycke. The chief point to be observed after asepsis is that the syringe should be absolutely free of moisture (anhydrous). The slightest moisture is liable to form hydrochloric acid with the Nastin solution and so cause necrosis and sloughing of the tissues.

6. A drawback to the treatment is the length of time during which it must be continued. It is however no worse off in this respect than the hypodermic treatment of syphilis. Patients get discouraged as they see no benefit at first, but when signs of improvement begin to appear they look forward to their weekly dose. Quite recently I had two more patients volunteering for treatment and a few lepers from the town having heard of it now want to come and take advantage of it.

7. In carrying out the treatment I have been assisted by Assistant Surgeons Anklesaria and Poredi and Hospital Assistant Manidharprasad S. Vyas to whom my thanks are due.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
1.	Daji Jiwa; aged 30; Hindu; a leper for 10 years.	Mixed tubercular and anæsthetic Leprosy. Fingers and toes thickened and tubercular. Face presents leonine aspect and is much swollen. Skin generally presents dry eczema with much desquamation. Blind of both eyes. Weight, 6·10 lbs.

Condition after 14 *weeks' treatment.*

The facial aspect is improved, especially marked in the condition of the ears and eyebrows. The skin presents a less thickened appearance. There is shrinking of the tubercular condition generally. The fingers and toes are less swollen and the eczematous condition improved. Patient states there is no return of sensation. Weight, 6·6$\frac{1}{2}$ lbs.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
2.	Rasulbux Niamatalli; aged 53; Musalman; a leper for 5 years.	Mixed anæsthetic and tubercular type. Thickening of skin of face and fingers. There is general stiffness of the finger joints with permanent anchylosis of the joint of the left little finger. Left ulnar nerve thickened and left femoral glands enlarged. Has a circular ulcer over end of left hypothenar eminence. Weight, 8·7 lbs.

Condition after 14 *weeks' treatment.*

The facial aspect is improved, the skin presenting a less thickened appearance. Patient states he has begun to experience return of sensation in the fingers. Further he is able to flex his fingers more than at first. Ulcer over left hypothenar eminence healed. He experiences

more pain at the time of inoculation. There is a decided general improvement. Weight, 8·8 lbs.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
3.	Shanker Trikam, aged 25; Hindu; a leper for 16 years.	Mixed tubercular and anæsthetic leprosy. Ulcers over fingers and toes which are stunted from atrophy. Diffuse eczematous ulceration over arms, forearms, thighs, and legs. Face clear. Left eye blind from Keratitis. General anæsthesia. Weight, 6 St.

Condition after 14 *weeks' treatment.*

Eczematous ulceration over both the extremities has healed. Patient states there is no return of sensation. Ulcer of hands and feet healed. Weight, 6·3 lbs.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
4.	Khengarji Manuji; aged 32; Hindu; a leper for 12 years.	Mixed tubercular and anæsthetic type. Nodules over fingers and toes which are stunted from atrophy. Face clear; Anæsthesia over both the extremities. Weight, 9·2 lbs.

Condition after 14 *weeks' treatment.*

Patient states there is some return of sensation. Weight, 9·3 lbs.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
5.	Chand Dildar; aged 30; Musalman; a leper for 10 years.	Mixed tubercular and anæsthetic type. Loss of fingers and toes from atrophy except left thumb and both great toes. Ulceration of stumps. Face clear. General anæsthesia. Weight, 5·4 lbs.

Condition after 14 *weeks' treatment.*

Ulcers healed. Patient states there is no return of sensation. Weight, 5·5 lbs.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
6.	Khima Vakha; aged 37; Hindu; a leper for 4 years.	Anæsthetic type. Limited anæsthetic patches over right forearm, upper part of left thigh and lumbar region of back. Weight, 7·13 lbs.

Condition after 14 *weeks' treatment.*

Patient states that there is some return of sensation in the affected parts. Weight, 7·9 lbs.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
7.	Sukha Baiju; aged 32; Hindu; a leper for 6 years.	Anæsthetic variety. Partial anæsthesia over limited areas all over the body. Fingers flexed. Toes thickened and shortened. Eczematous eruption over forearms, external surface of thighs and legs. Itching sensation over the body. Slight thickening of skin of face. Weight, 7·8 lbs.

Condition after 14 *weeks' treatment.*

Has begun to feel a return of sensation in the upper extremities. The eczematous condition has improved with subsidence of itching sensation. Weight, 7·11 lbs.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
8.	Chiklo Bhula; aged 21; Hindu; a leper for 5 years.	Anæsthetic type. Eczematous eruption of arms and legs with marked flexure of fingers. Itching sensation all over the body. Left femoral glands enlarged. Anæsthesia of both the upper and lower extremities. Weight, 6·10 lbs.

Condition after 14 *weeks' treatment.*

The eczematous eruption over the arms has cleared up whilst that over the legs is improving. Subsidence of itching sensation. Patient states there is some return of sensation. Weight 7·4½ lbs.

Serial No.	Name, Age, Caste, how long ill.	Condition before commencement of treatment.
9.	Dhula Jetha; aged 57; Hindu; a leper for 10 years.	Mixed tubercular anæsthetic leprosy. Loss of great toes. Fingers flexed. Eczematous eruption over lower extremity. Itching sensation all over the body. Anæsthetic patches over the extremities, more marked in the upper ones. Weight, 5·5 lbs.

Condition after 14 *weeks' treatment.*

The eczematous condition is improved. Subsidence of itching sensation. Patient states there is no return of sensation. Weight, 5·6½ lbs.

DISCUSSION.

Dr. Arthur Powell. had seen so many "cures" vaunted for leprosy that he feared he was somewhat too sceptical in his views.

It must not be forgotten that many cases of leprosy improved temporarily: he knew of one at least that was to all intents and purposes cured without any treatment.

He had, as one of the Committee of the Asylum, opportunities of seeing the Matunga cases treated by Nastin. Undoubtedly all round the results were encouraging, some were improved, a few were worse, none were cured. He had seen much better results with many vaunted specifics. In his own hands he had seen very much greater improvement with hypodermic injections of Perchloride of Mercury, which, however, were in most cases excruciatingly painful. The nearest approach Dr. Powell had seen to cure was with alternating injections of Perchloride and Coley's fluid, but he had seen such severe reaction with the latter, (obtained from the British Institute of Preventive Medicine) that he had abandoned it as dangerous.

He was much struck by Professor Deycke's photographs. No one was more sadly aware how photographs could mislead. Dr. Powell had given Sir Jonathan Hutchinson some photos which he had published, and pointed out as "typical phagadæna," some milk spilt on the patient's skin!

But taking photos for what they were worth, the most completely cured of Professor Deycke's cases appeared to Dr. Powell a typical case of Yaws. The photo certainly gave

no suggestion of Leprosy to any one who had ever seen Yaws. The granulomata on the skin all seemed fungating and uncovered by epidermis. He passed round a number of photographs of Yaws to show the resemblance. The patient represented in one photograph, remarkably like Professor Deycke's in size, distribution and character of the granulomata, was shown two years later, after a persistent course of expectation, as completely cured as if he had been given Nastin.

Dr. Powell hoped he was not throwing too much cold water on the treatment. Capt. Williams' cases certainly appeared vastly improved and to justify his enthusiasm. As regards the conclusions as to improvement drawn from the acid-fast character of the bacillus, it was to be hoped each investigator would set himself a standard solution of stain, of acid, of heat, of time for staining and of time for applying the acid. Otherwise by the least unconscious jugglery results could be produced to order.

The Matunga cases had not had the Nastin pushed to the same extent as in Capt. Williams' cases, a point which he hoped to see remedied if the patients would consent.

Professor Musgrave said he had seen Prof. Deycke's photograph referred to by Dr. Powell and had been surprised to hear it was a case of leprosy. It seemed to him as far as photos could be judged an undoubted case of Yaws.

Dr. Bawa said the photographs in question were of the disease they called " Paranghi" in Ceylon, and not Leprosy.

THE BACTERIOLOGY AND TREATMENT OF LEPROSY.

By Major F. A. SMITH, M.D., D.P.H., I.M.S., and Capt. E. BISSET, M.B., Ch.B., I.M.S.

When the postulates of Koch are applied to the leprosy bacillus its specific nature remains non-proven; the organism is invariably associated with the disease; many observers claim to have cultivated it in artificial media without the body, but susceptible animals for inoculation from the cultures are not forthcoming: the inconclusive animal experiments that have been done will be noted later.

However, while awaiting the complete demonstration, which will not only be of academic interest, but of vital importance in the treatment of the disease, we may take it for granted as a working hypothesis, in confirmation of which there is much collateral evidence, that the bacillus discovered by Armauer Hansen in 1871 and definitely associated by him with the disease in 1877, and by Neisser in 1879, is the causative agent of leprosy.

We may note in passing that it was not until eleven years after Hansen's first observations that Koch announced the discovery of the tubercle bacillus.

The leprosy bacilli are usually thin rods measuring from 5μ to 6μ long and $0{\cdot}3\mu$ broad; they are rarely straight, more often slightly curved, they usually occur singly, or two may be attached end to end, chains are not found: as far as is known they are non-motile, but Babes* found them slightly motile, and claims to have found branching forms in cultures. Many, according to Macé, present an unstainable peripheral gelatinous zone. They are more constant in size and a little shorter than the tubercle bacillus. Lehmann and Neumann, quoted by Coles,† give the following differential points; in leprosy the bacilli are more abundant and appear in heaps like a cigar in form, in tubercle they are less numerous and occur either singly or in irregular bunches: after staining the granules in bacilli lepræ are coarse and widely separated and in tubercle bacilli fine and close together.

When stained there is often a fragmented appearance of the protoplasm; they appear tapered at one or both ends and there are sometimes two or three club-like swellings 2μ in diameter which have been considered as spores.

The staining reactions are as follows:—

They stain with ordinary aqueous solutions more readily than tubercle, they are Gram's positive and stain by Erhlich's and Ziehl-Neelsen's method.

They resist decolouration by acids but to a less extent, according to Muir, Ritchie, and Woodhead, than do tubercle. Macé‡ however states that they resist acids better than tubercle. Our own observations upon this point show that while tubercle bacilli appear red after 24 hours' immersion in 25% sulphuric acid, leprosy bacilli, which at the end of each hour up to 16 hours, remain well stained, lose their stain after 18 hours' treatment; they are thus according to Coles' table more resistant to acids than all acid-fast bacilli except tubercle in sputum. The method we adopted was to place on the same slides, smears of both bacilli to ensure that in each case they received the same treatment.

The two bacilli were also similarly compared by Honsell's method, namely, after staining, washing, and drying, by immersing for certain periods in a 3 per cent. solution of hydrochloric acid in alcohol, and then counterstaining in a saturated alcoholic solution of methylene blue. Up to 12 hours the tubercle bacilli retain their stain: after two hours the lepra bacilli remained well stained, after three hours very few could be distinguished, and after 6 hours only one or two very faintly reddish bacilli were seen. These results again place the bacilli in the same position as to their power of resistance relative to other acid-fast bacilli.

We venture to suggest that in these staining reactions lies the best method of clinically differentiating leprosy and tubercle in cases where either doubt exists or there is a question of a mixed infection.

The cultivation of the bacillus of leprosy in various media has occupied the attention of many bacteriologists for many years. Several have claimed to have solved the problem, but in most cases their observations have not been confirmed.

Four years ago Major Rost of the I. M. S. published an account of his method of growing the bacillus, and he used an emulsion of his growth, leprolin, as a vaccine

Der Lepra Bacillus and die Histologie der Lepra, Berlin, 1898.
Clinical Diagnostic Bacteriology.

‡ Traite de Bacterologie, 1901.

with, in many cases, encouraging results. Col. Semple on behalf of the Government of India was asked to investigate these observations and found the bacillus was not that of leprosy. The result was that the use of leprolin was discouraged. We hope in to-day's discussion to hear further details regarding this material.

Neisser placed portions of leprous tissue on coagulated blood serum, which in three weeks' time gave small prominent colonies as large as a millet surrounded by a hyaline zone.

Bordoni-Uffreduzzi* obtained cultures with glycerinated media at a temperature of 37°; the growth was very slow. On peptonized and glycerinated serum the colonies had sinuous borders and were of a slight yellow colour: the medium was not liquefied.

On glycerinated gelatin they grow in small round colonies, with serrated edges, slightly greenish in colour: plate cultures show a compact centre with sinuous edges.

Ducrey† claims to have obtained stabcultures in glucose gelatin, but his bacillus differs from that of Bordoni-Uffreduzzi.

Babes obtained cultures on serum and on gelatin of an acid-fast organism.

Czaplewski‡ in a culture on coagulated serum, made from the debris of leprous ulceration in the pharynx, amongst other organisms obtained small irregular greenish-yellow colonies consisting of fine curved bacilli which he grew without difficulty in ordinary media, and obtained the best results with Löffler's medium of blood-serum peptone broth. His bacilli took ordinary stains, retained Gram's stain, and were slightly alcohol and acid-fast; in older colonies they became irregular, as occurs also with tubercle resembling Unna's Cocothrix. In broth he described numerous involution forms.

Spronek§ obtained growths on potatoes inoculated with the serum from leprous tubercles; after 10 days, at 33°, the colonies were quite small of a pale yellow colour; the bacilli were decolorized in acids, and resembled Löffler's bacillus. They grew easily on various media, and Spronck found that the addition of 5 per cent. glycerine and 5 per cent. glucose accelerated the growth. The colonies also grew without oxygen but more slowly.

These bacilli were agglutinated by the serum of lepers.

These observations were repeated and confirmed by Teich in 1899‖ and both observers concluded that they were dealing with the true bacillus of leprosy.

Investigations did not lead to any practical results, either in the prophylaxis or the treatment of the disease, until Dr. Deycke Pasha and Dr. Reschad Bey took up the subject; and their work, to which we shall refer in some detail, is a monument of accurate scientific research and deduction which seems to have solved the problem of the treatment of this disease, and will materially assist the physician in dealing with certain other diseases. They describe their cultivation as follows:—

"Sterilize in the autoclave good unskimmed milk in Erlenmeyer bulbs, so that, after cooling, a distinct layer of cream, not a skin, floats on the non-browned milk. Inoculate the surface, *i.e.*, the layer of cream, with sufficient quantities of culture material, and keep the bulbs at a temperature of about 30°C. Within fourteen days there forms on the surface a thick massy culture membrane of a splendid orange tint, which can easily be removed *in toto*, and which microscopic examination shows to consist of an interlaced felt-work of acid-proof rodlets and bacillary fragments."

The material from which the cultures were made was obtained by throwing back a flap of skin including a non-ulcerated recent leproma, and taking fragments of tissue from the undersurface of the leproma.

The organism grown is not the lepra bacillus in the form in which it is seen in the tissues, but is a streptothrix, named by the authors the streptothrix leproides: it invariably grows from the leprous tissue and is, in some not fully understood manner, derived from the lepra bacillus, which in staining reactions it resembles.

The *inoculation* of leprous tissue subcutaneously into rabbits has led to a certain amount of induration around the seat of inoculation, and the bacilli, weeks afterwards, may be found unchanged, but no multiplication of the organism takes place. Melcher and Orthmann inoculated the anterior chamber of the rabbit's eye with leprous material and found afterwards an extensive growth of nodules in the lungs and elsewhere containing leprosy bacilli; these results however have been questioned.

Arning describes the case of a criminal in the Sandwich Islands who, two years after inoculation with leprous tissue, developed leprosy, but he had been exposed to infection previously and may have contracted the disease through the ordinary channel.

Tedeschi¶ inoculated the brains of monkeys with leprous material, the animals died in six days, and from the meningeal serum he obtained numerous lepra bacilli.

Nicolle quoted by Max** also succeeded in inoculating a monkey, and producing a hard subcutaneous growth from which lepra bacilli were recovered.

Classification.—The bacillus lepræ on account of its staining properties falls naturally into the category of acid-fast bacilli, which includes tubercle, the timothy grass, the cow dung and grass bacilli of Möller, the butter bacillus of Rabinowitsch, the tonsillar bacillus of Marzinowsky and that obtained by Rabinowitsch from a case of pulmonary gangrene. These are often filamentous and occasionally show true branching, as does Bacillus Diphtheriae and Bacillus Mallei, which again suggests their close relation to the growth from lepra bacilli obtained by Deycke.

It has been proposed to class them all as streptothrix; but, before this can be definitely done, investigation into the chemical nature of streptothrix will be necessary,

* Ueber die Cultur der Leprabacillen (Zeitshv. für Hygiene III).

† Giorn. ital. delle mal. vener. e della pelle, 1892.

‡ Centralbl für Bakt. XXIII, 1898.

§ La culture du Bacille de Hansen et de Séro-diagnostic de la lepre (Sem. med., 28 Sept. 1898).

‖ Centralbl. für Bakt. XXV, 1899.

¶ Ueber die uebertragung der lepra auf Thiere (Centralbl. für Bakt. XIV, 1893.)

** Arch. für Schiffs. und Trop. Hyg. August, 1906.

especially if their chemical constitution is to be looked upon as of generic importance. Many streptothricæ are known to be acid-fast, a fact which suggests close relationship to the pathogenic organisms classified according to this property.

Chemical Constitution.—The difficulty of staining tubercle bacilli and their acid and alcohol-fast properties depend according to Bulloch and Macleod upon the presence of a wax which can be extracted with hot alcohol and ether from the bodies of the bacilli: from the remains of the bacilli when further extracted with caustic potash they obtained a chitinous substance which, like the wax, was also acid-fast when treated for 24 hours with carbol-fuchsin.

Professor Deycke treated his mycelial growth in a Soxhlet apparatus for several days, and extracted, in addition to the milk-fat, a fatty substance from the streptothrix: the bacterial debris remaining he stained by the Ziehl-Neelsen method and they appeared blue.

The fat obtained was of a deep red colour. It was freed from ether and heated over a water-bath in pure alcohol, from which in two or three days' time a voluminous thick flaky precipitate separates. This was found to be a genuine fat, and is probably a simple chemical substance, namely, a combination of glycerine with a high molecular fatty acid. This is the substance to which the name Nastin has been given.

Treatment.—The great variety of drugs recommended for leprosy exposes our ignorance of any satisfactory treatment in the past. The fact that the disease is liable to periods of exacerbation and quiescence and also that mere improvement in the patient's general hygiene induces an improvement in many of the most distressing symptoms has no doubt lead to a mistaken belief in the efficacy of certain drugs.

The use of local applications, in view of our knowledge of the pathology of the disease, is obviously very limited. Ulcers on the extremities are in the majority of cases the result of trauma due to anæsthesia, and tend to heal with ordinary care.

Once the disease is established with profuse lepromata or extensive nervous disturbances, it is impossible to believe that local applications of Icthyol, Caustic Paste, Chrysophanic Acid or any other drugs can be of any curative value whatsoever.

X-rays have been strongly advocated by Heiser, and several other writers report an improvement in cutaneous lesions but nothing further has resulted.

In the Sehore Asylum out of 46 patients 30 give a history of nasal discharge as one of the earliest symptoms and 41 have active ulceration of the nasal mucous membrane. In the nasal discharge of these 41 lepers the bacillus lepræ was found, usually in great abundance. This ulceration is therefore a definite leprous lesion in contrast to the ulceration of the extremities. We failed to find the bacillus in ulcers of the extremities except in those caused by breaking down lepromata and this is not the common form of ulceration found in leprosy. Most ulcers are purely traumatic.

It would appear that the nasal mucous membrane is the site of infection of the individual and also is the fountain from which bacilli are shed into the world. The nasal ulceration is definitely connected with the onset of the disease and, in our opinion, is sufficient to class leprosy in the early stages of the disease as a local inflammatory process in contradistinction to septicæmia or intoxication.

The first essential of treatment is clearly the thorough disinfection of the nose and, if possible, the destruction of all infection *in situ*. It is conceivable that if a case is taken early enough such treatment would abort the disease For this purpose the thermo-cautery or some strong bacteriacide should be employed and the best we know among the latter is that recommended by Andrewes in the *Lancet* of October 1905, namely ammonium persulphate 3·7 per cent. and hydrochloric acid 1 per cent. in water.

Some time ago an undated pamphlet came under our notice written by the late Brigade-Surgeon Parker describing a process of treating leprosy by sulphurous acid fumes. A cage, not unlike those used for drying clothes in the monsoon, is prepared with a hole in the top; the patient sits on a stool with his head projecting through this hole. About ¼ lb. of sulphur is burned in a pan under the stool and the whole is surrounded by blankets carefully adjusted to prevent the fumes escaping. This is done for half an hour twice daily. Between August 1907 and July 1908 a number of patients in the Asylum at Sehore was placed on this treatment. Several cases showed marked improvement. Anæsthesia of the extremities to a large extent cleared up and ulcers rapidly healed. Leprous growths, however, showed little change and no improvement was noticed in the nasal ulceration. Dr. Parker hoped he had discovered a cure, but this after more than a year's trial has not been justified. At the same time the rapid improvement in sensation is very gratifying to the patient and the treatment might advantageously be combined with others. A curious point is that improvement is also noticed in the sensation of the face when this is affected, so that the action is apparently constitutional as well as local. Encouraged by this fact, we have, to some patients, administered sulphur internally in addition to the baths, but have no definite results to report.

Amongst the many drugs recommended for internal administration probably Chaulmoogra Oil alone has any real effect. Administered in sufficient doses there is usually a distinct improvement. Cures have been reported after pressing the drug. At the same time there is little doubt that lepers frequently recover spontaneously; all cases do not react to Chaulmoogra Oil, and many do not tolerate the drug on account of the nausea produced. On the whole the treatment of leprosy was on a most unsatisfactory footing till Professor Deycke in 1906 published his work on treatment by benzoyl nastin. They found that injections of cultures of the steptothrix leproides had a favourable influence on several leprous patients. After some time they came to the conclusion that the active principle in the cultures was the neutral fat named by them nastin. A similar fat

they found to be present in Hansen's Bacillus, to the presence of which it probably owes its resisting powers. At first Deycke thought that the injections of nastin produced an acquired immunity to this fat and that after its removal the organism readily killed the unprotected bacilli. Later, however, he noticed that patients who exhibited an active reaction to nastin also developed a pronounced leucocytosis while those who did not react showed no increase of leucocytes.

The idea therefore occurred to him to produce an artificial leucocytosis by injecting cinnamic acid. He did so and when the leucocytosis was well marked injected nastin. The result was an immediate pronounced reaction.

Leucocytosis by itself had no result.

After repeated experiments it was noticed that an injection of nastin mixed with cinnamic acid also produced a pronounced reaction without, however, any marked leucocytosis. It was therefore presumed that cinnamic acid or some allied substance was essential to assist the nastin or, as Deycke says, to sensitize it. The physiological chemistry of cinnamic acid was known. It is excreted as hippuric acid which is synthetised in the kidneys, at any rate in dogs, from glycocoll and benzoic acid, and benzoic acid is one of the late products of oxidation of cinnamic acid, so he concluded that the best substance to assist his reaction was either of these substances or one of the intermediate products of oxidation. First he examined benzaldehyde, which was found no better than cinnamic acid, and then benzoyl chloride, which proved to be much more active than any of the others. In vitro he found it readily removed all fat from his streptothrix and also from tubercle bacilli; and, injected hypodermically with nastin, it induced an immediate and pronounced reaction.

Benzoyl chloride injected by itself had no effect and Professor Deycke is of opinion that it being so very active goes immediately into combination with other organic substances in the body.

His theory, and it is probably the correct one, is that nastin only acts as the carrier. It goes into loose combination or simple solution with the benzoyl chloride and retains it till it reaches the lepra bacillus.

Nastin is inactive unless there happens to be leucocytosis at the time of injection or unless the benzoyl radicle is also injected. The action of cinnamic acid is well known and the conclusion that Deycke then came to was that leucocytosis from any cause gives rise to the presence of the benzoyl radicle in the circulation and obviously the best manner of ensuring the reaction was not to rely upon the physiological supply but to administer it with the nastin.

By this somewhat involved process of reasoning the conclusion which forms the basis of this treatment is clear, namely, that the benzoyl chloride carried to the bacilli by the nastin deprives them of their armour of fat and delivers them up to the tender mercies of the white blood corpuscles.

While attempting to arrive at the proportions in which nastin and benzoyl chloride should be mixed, a curious point came out, namely, that if a solution of benzoyl-nastin was injected in which nastin was in excess, severe reactions frequently occurred. Mixed in the proportion of nastin 1 and benzoyl chloride 20 in vitro, nastin was sometimes deposited at ordinary room temperatures whereas mixtures in the proportion of nastin 1 and benzoyl chloride 30 always remained stable, therefore this was about the proportion of nastin benzoyl chloride could hold in solution. Injections of the former produced reactions, whereas the latter rarely did. Again, injections of the latter if administered at too short intervals did cause reactions, and the presumption is that the very active benzoyl chloride is much more rapidly taken up by the organism than the rather inert nastin which accumulates in the system.

The question of the reaction is rather shrouded in mystery. At the beginning of his investigation Professor Deycke's aim was to obtain a reaction, which he did by sensitizing the nastin, and at that stage he looked on this substance as the curative agent. Later it was clear that such was not the case. The treatment is essentially a solution of the fatty envelope of the bacilli *in situ* by benzoyl chloride leaving the naked bacilli to be removed by ordinary physiological processes.

General reactions are to be avoided.

In the nodular form of the disease extensive sloughing and necrosis accompanied by high fever may take place owing to the too rapid breaking down of leprous tissues and poisoning by endotoxins from the bacilli.

In cases of lepra nervorum, too vigorous treatment may be immediately followed by extensive and deep ulceration and pemphigoid eruptions in the anæsthetic parts. This Deycke attributes to inflammatory changes in leprous nerve centres and this theory reminds one of the pathological changes found in the dorsal nerve roots and ganglia in severe cases of Herpes Zoster.

Having given a brief resumé of the steps by which Deycke arrived at his results we proceed to give a few details based on the published, as well as our own, results regarding the application of the treatment.

Patients in whom the internal organs are affected should be excluded from treatment. Those with eye affections or extensive nervous disturbances must be treated cautiously. In the former any reaction might cause glaucoma or dense clouding of the media, while the latter are apt to exhibit those extensive trophic lesions in the skin already referred to.

For therapeutic purposes benzoyl nastin is prepared in three concentrations called for brevity Nastin B0, Nastin B1, and Nastin B2. In the last, nastin is present in excess and should only be used in patients with very persistent neoplasms. It is liable to cause reactions, and is absolutely negatived in opthalmic and nerve leprosy.

Nastin B1 is the standard solution for ordinary use and it should cause no reaction unless pressed too rapidly. A fourth solution, called "K," consisting of benzoyl chloride alone should be kept at hand during the treatment as it has been found to be most efficacious in shortening and reducing the severity of reactions when these appear.

Each case must be carefully estimated, watched and dosed accordingly and, on the slightest sign of a reaction, treatment should be stopped till it has passed off. In the Sehore Asylum we found that after the second or third injection a faint red flush appeared on and around lepromata, accompanied by some itching. This, however, rapidly passed off.

Benzoyl Nastin is administered subcutaneously commencing with 1 cc.m. weekly and in mild cases gradually reducing the interval till in suitable patients 1 cc.m. is administered daily. The syringe must be of the "all-glass" type with a platinum needle. It must be anhydrous. This is conveniently accomplished by sterilizing in the ordinary way and then keeping permanently under ether. If any water is injected with the solution local abscesses may appear, due to the formation of hydrochloric acid. As a further precaution, the skin, after it has been thoroughly scrubbed with soap and water, should be rubbed over with a strong solution of biniodide of mercury in alcohol.

As the treatment depends to a large extent on purely physiological processes recovery will of necessity be slow, and extend in the majority of patients over many months, resource must be had therefore to surgical measures wherever possible to expedite recovery by aiding nature and to prevent the onset of the many troublesome complications which accompany the disease.

From the first the nasal ulceration should be treated with the thermocautery or cleansed with the ammonium persulphate solution.

Iridectomy, tarsorrhaphy, tracheotomy, excision of very persistent lepromata and necrotomy must be performed when indicated. Surgical wounds in leprous patients heal without noticeable delay.

In October 1908 we commenced treating a few patients with Nastin. We had for some months previously been using Dr. Parker's Sulphur Baths and Chaulmoogra Oil. The patients, of whom 95 per cent. are Hindus, are natives of Bhopal and the surrounding States. Few of them wished to be treated regarding their case as hopeless. The women particularly resented our experiments and were in fact for a time almost mutinous. We accordingly selected four of the more intelligent men who were anxious to be cured. We commenced with Nastin B0. They were emphatic about an immediate improvement and after they had had two injections each, the remainder of the men clamoured for treatment, and, in a short time, several women volunteered including one of those who had originally been the most obstinate. With few exceptions all were unanimous about an immediate and extraordinary feeling of lightness and *bien-être*, combined with a great improvement in appetite.

The following are brief notes of some of the twenty cases that have been treated :—

Case 1.

Parma, son of Ghasi Ram, aet. 51.

Duration of disease 16 years.

At the beginning of September 1908 this man complained of shooting pains in his legs and arms. The eyebrows, cheeks, nose, and ears were covered with prominent nodules and smaller isolated nodules were scattered up and down the extensor aspects of both arms. The hair of the eyebrows was almost gone and there was commencing ectropion of the right lower lid.

The 2nd, 3rd and 4th fingers of each hand had dropped off ; and the thumb and first fingers were deformed and ulcerated and the nails unhealthy. Both feet and ankles were much swollen and the great toes ulcerated round the nail. The nails of the other toes were thick and unhealthy. He had partial anæsthesia of the right arm and complete anæsthesia of the left fore-arm and hand. Sensation was also much reduced in both lower limbs. Towards the end of September the lepromata became more marked. Ulcers were deepening and there is a note to the effect that there was profuse perspiration. Complete anæsthesia had developed over the whole body so that a pin could be stuck deeply into any part without the patient's knowledge.

On the 3rd October 1908 injections of Nastin B0. 1 cc.m. weekly were commenced. By the 31st of the same month the shooting pains were no longer complained of and the nodules on the face showed a red flush. Sensation of the arms, face and body was normal, and only partial anæsthesia of the legs and feet remained. On this date injections of Nastin B1 were commenced. On the 5th December 1908 a leproma on the face was tending to ulcerate and break down and an ulcer had appeared on the ball of the right foot.

About the 12th December a superficial weeping eczema appeared on both feet and legs accompanied by a slight rise of temperature. Injections were discontinued but the lesion got gradually worse till on the 26th December ½ cc.m. of "K" was administered in the hope of aborting the reaction. Two days later both feet swelled up and deep ulcers and bullae formed over the feet and ankles, and a pemphigoid eruption appeared on both thighs accompanied by a slight rise of temperature. All the lepromata on the forehead showed a tendency to break down and ulcerate. For a few days the condition got worse and then improvement set in with slow and steady healing of the lesions.

On the 27th January 1909 the facial nodules had all become greatly reduced. Those on the nose and right ear had completely disappeared. Only a few remained on the cheeks. The hair of the eyebrows was commencing to grow and there was no sign of ectropion. All the original ulcers had healed up and only those which resulted from the reaction remained covered with dry scabs. All the toe nails were growing and there was not a trace of anæsthesia.

Case 2.

Bhawani, son of Kouraji, aet. 25.

Duration of disease 9 years.

In September 1908 this man showed very marked leontiasis. The eyebrows, lids, cheeks and nose were thickly covered with massive lepromata. Both lips were so greatly swollen that the skin was tense and glazed and the mouth could only be opened with difficulty.

The tongue was swollen, indented by the teeth and covered with thickend white patches. The roof of the mouth was ulcerated and the voice hoarse.

There were a number of nodules on the lower part of the back of the right fore-arm and in the first interosseous space and there was a large foul ulcer on the lower end of the ulna.

The nail of the right thumb was gone and those of the fingers much atrophied. All the fingers were ulcerated and deformed.

The left arm and hand were in a very similar state.

There was partial anæsthesia of the right hand and of the left fore-arm and hand.

There was a thickened doughy feeling on the outside of the calves of both legs and an ulcer on the ball of the left foot.

There was complete anæsthesia over the knee caps and partial anæsthesia of both legs and feet. The septum nasi was extensively ulcerated.

Treatment by Nastin BO. 1 cc.m. weekly was commenced on the 10th October 1908 and on the 31st this was changed to Nastin B1.

Improvement was noticed almost from the first, and on the 14th November lepromata had been so much reduced that the skin of the face had become loose and wrinkled.

By the 27th January 1909 the nodules on the forehead had completely vanished. Those on the cheeks were markedly reduced and the original massive infiltration of the lips was commencing to resolve into more or less isolated lepromata. The same change was noticeable in the calves of the legs. The nail of the right thumb had begun to grow and thin nails were forming on the other fingers.

Sensation of the arms and hands was normal, but in this respect no change was noticed in the lower extremities. All the old ulcers had healed, but a fresh one had developed on the knuckle of the left fore-finger.

Case 3.

Bawalia, aet. 50, male.

Duration of disease $1\frac{1}{2}$ years.

On admission in November 1908 the most marked symptom was extensive leucomatous patches scattered over the abdomen, back, neck and extremities. Most of these patches were edged by a pale pink papular eruption. The feet were ulcerated. There was complete anæsthesia in both fore-arms, hands and both legs.

Treatment by Nastin began on the 21st November 1908. On the 28th January not a trace of anæsthesia remained with the exception of the dorsum of the left foot where there was still some alteration in sensation. The white patches on the arms were much less obvious and the papular eruption had completely disappeared. The ulcers on the feet had completely healed.

Case 4.

Umrayia, daughter of Ghasni, aet. 20 years.

Duration of disease 9 years.

In September 1908 this woman's forehead, cheeks, nose, lips and chin were swollen with large diffuse lepromata. The bridge of the nose was sunken and the septum ulcerated and discharging. The uvula was ulcerated, the tongue cracked, the voice hoarse and the breath fetid. Scattered over the epigastrium was a pink coloured papular eruption. A similar eruption was present over the extensor aspects of both arms. The hands were greatly swollen, the fingers deformed and ulcerated, and the nails were present, in a very unhealthy condition. There was partial anæsthesia of the face and right hand.

Treatment by Nastin began on the 21st November 1908. By the 27th January 1909, the lepromatous tissue in the face had become greatly reduced. The eruption on the abdomen had disappeared. The ulcer on the uvula had healed, the tongue was in a healthy condition and the voice was clearer. An atrophied nail of the left thumb was about to fall off and a healthy nail was growing from the bed. Ulcers had all healed and there was no anæsthesia.

Case 5.

Kadhori, son of Mulla, aet. 32 years.

Duration of disease 12 years.

In September 1908 he was lethargic and mentally slow.

The eyebrows, cheeks, lips and ears were thickened, and over the left eye there was a large patch of eczematous appearance covered with dry scabs.

The moustache and beard had almost disappeared. The nasal septum and the roof of the mouth were ulcerated. There was partial anæsthesia of the right fore-arm and some of the fingers were deformed. Except for numerous scars and partial anæsthesia of the back of the hand the left arm was normal. Both feet were swollen, the right ulcerated, and all the nails unhealthy. Certain areas of the feet and legs were completely anæsthetic while others had normal or nearly normal sensation.

Treatment by Nastin began on the 10th October 1908. After the 4th injection the difference in the man's mental condition was most marked. No anæsthesia remained. The lepromata on the margins of the ears were tending to ulcerate and a faint red flush had appeared on the forehead. The scaly patch over the left eye was weeping. Treatment was continued, and, by the 5th December 1908, this patch had faded into small isolated areas and a boil due to a breaking down nodule had formed on the left side of the nose. On the 26th December only a small part of the eczematous patch remained which, however, was discharging thin pus. The thickening of the face had almost gone, but the balls of both feet were ulcerated. Treatment was then discontinued.

On the 27th January 1909 no thickening of the face remained except on the ears, where it was greatly reduced.

The remaining part of the eczematous area was dry and slowly fading. All the originally unhealthy nails were growing and also the beard and moustache.

Case 6.

Dauli, daughter of Anopa, æt. 20 years.
Duration of disease 2 years.

This patient is a severe case of nodular leprosy. The nodules have steadily and slowly shrunk under injections of Benzoyl Nastin. Treatment was for a time interrupted by an active local reaction confined to a large leproma on the nose. Her case has been particularly interesting, because one could observe microscopically the commencement of bacteriolysis as evidenced by the removal of fat from the bacilli when smears of serum expressed from nodules were stained.

With regard to segregation, it is now practically unanimously agreed that leprosy is contagious though only feebly so. The disease, moreover, has in the past proved so intractable and its various symptoms are so repulsive that nothing short of strict segregation can be seriously considered. Treatment even by Benzoyl Nastin is bound to extend over several months. The majority of lepers, during the active period of the disease, are shedding myriads of bacilli from the nose. Strict segregation has in the past proved to be a certain method of preventing the spread of the disease and it is extremely doubtful if any modified form of isolation would be as efficacious. Amongst our patients, however, there are 6 in whose nasal secretions repeated examinations have failed to demonstrate any bacilli though there are signs of previous ulceration of the nasal septum. Some of these have lost all their fingers and toes or have well developed *main-en-griffe*. They have anæsthesia in the arms and legs from the elbows and knees downwards respectively. They occasionally suffer from traumatic ulcers, but we have failed to show that they are discharging bacilli into the outer world. In our opinion these patients are no longer contagious and might with impunity be discharged from the Asylum. Moreover, they are liable to become reinfected and on this account we are inclined to advocate a more individual segregation. The duration of the disease in these 6 cases averages 22 years. In them the disease is probably worn out. That this may occur has been pointed out by many observers.

Possibly stray bacilli exists in the deeper nerves, but as long as they remain there they cannot be a source of danger to others. In our patients little hardship is being caused by confining them. If discharged they would certainly infest the roads begging and exhibiting filthy neglected sores to excite compassion. In other countries, however, the same conditions do not prevail. These patients are suffering from the effects of leprosy —not from leprosy. When by repeated examinations of the nasal secretion no bacilli lepræ can be demonstrated, we think the patient can safely be liberated from segregation. It has been stated (Impey) that purely anæsthetic lepers are not infectious. This we have found not to be the case, as although the majority of our patients are cases of mixed infection a number are of the purely anæsthetic type and in them also we have proved the presence of bacilli in the nasal secretion.

We must acknowledge the assistance we have received from Hospital Assistant Ram Sahay in staining and examining specimens and in the tabulation of notes.

THE TREATMENT OF LEPROSY BY MEANS OF NASTIN INJECTIONS.

By J. S. P. RODRIGUES, L.R.C.P. AND S. (Edin.), L.F.P.S. (Glas.).

The treatment of leprosy by means of Nastin injections has been carried on by me at the Acworth Leper Asylum since January last when I took over charge from Dr. D. A. Turkhud. Nastin is a discovery of Prof. Dr. Deycke Pasha and Senior Physician Reochad Bey of the Imperial Ottoman Hospital and Medical School, Constantinople.

The method of preparation, its theoretic significance as an immunizing substance in leprosy and its application in practice is contained in an essay published by them, and which can be obtained from Messrs. Kahn and Kahn, who are the local agents for Nastin. Nastin is injected hypodermically, and the syringe used must be made of all glass. Before using I always have my syringe thoroughly dry and free from water as otherwise abscesses are liable to result at the site of injections.

The method that I use is the following. After the injections are over I have the syringe thoroughly washed in carbolic lotion (1 in 40), then I have it dried and immersed completely in æther sulphuris, till it is to be used again, when it is taken out and dried over a spirit lamp and then it is ready for use. When many patients are to be injected at one time I have the needle passed through the flame of a spirit lamp each time before the injection.

I have had no abscesses except in 3 cases when the injections were not made by me and I think it was due to the carelessness of the man who cleans the syringes.

I have been trying Nastin injections on 35 patients. Out of these 7 have given it up because they either find the injections painful or their eyesight became cloudy. One died and another one is bad with dysentery.

I have not had any control cases with this treatment, as it is difficult to get two cases alike owing to the difference of diet, mode of living, age, occupation, and especially type and duration of disease, as there is in certain cases a tendency to spontaneous cure after a very prolonged period. I have an example of such a case at this asylum.

I will now briefly relate some of the cases that have

been under this treatment, giving a short history and the subjective and objective signs of improvement that they feel.

CASE No. I.

Luis Mascarenhas, age 35 years, Christian, male, native of Goa. Tubercular leprosy. Ill for 18 years. Father had leprosy.

Has been under treatment since 30th August 1907. Has had 16 injections of Nastin B 1 and 35 injections of Nastin B 2.

Three years after the appearance of the disease he had been under the treatment of some native herbalist for 7 months, after which he felt all right and worked for 5 years as a barman when the tubercles appeared again with greater force. He resorted to the same man for relief and again felt himself completely free from the disease, and then worked as a cook for three years when the disease appeared again and he came to this asylum.

The effect of the treatment has been the following. The frequent exacerbations of the disease have now stopped. The tubercles from the body have nearly disappeared or softened. Complains of an itchy feeling over the abdomen only for the last six months which disappears if the injections are discontinued for a time. I may mention here that the itching sensation that he feels is just over the parts where he was injected before at Kasauli where he was undergoing the Pasteur treatment as he was bitten by a mad dog.

The ulcers on the back of the elbow joints and the foot have healed up. The swollen appearance of the face is less due to the lipomata (leprous) decreasing in size, and he has kept on a constant weight of 4 maunds 4 lbs. all along during the treatment.

His general health has been very good.

CASE No. II.

Domingo Collaco, age 18 years, Christian, male, native of Bassein. Tubercular leprosy. Ill for 6 years. No family history.

Has been under treatment since 29th January 1908. Has had 6 injections of Nastin B 1 and 22 injections of Nastin B 2.

The tubercles from the face are disappearing; the tubercles from the ears and buttocks have disappeared and the ulcers on the feet have healed up. He has had no exacerbations of the disease since he started the treatment. He has regained the sensibility of the parts supplied by the ulnar nerve. His general health has been very good and his weight during the treatment has increased from 3 maunds to 3 maunds 7 lbs., that is a gain of 7 lbs.

CASE No. III.

D. M. Fernandes, age 38 years, Christian, male, native of Goa. Tubercular leprosy. Ill for 20 years. No family history of leprosy.

Has been under treatment since 11th February 1908. Has had 5 injections of B 1 and 23 injections of B 2.

The tubercles have all disappeared from the body. No exacerbations of the disease since he started the injections. Anæsthesia of both hands and left leg the same. The want of energy, dulness and inability to walk for a long distance has disappeared. He feels just as lively as before. Keeps very good general health and his weight during the treatment has been from 3 maunds to 3 maunds 2 lbs.

CASE No. IV.

Caridade Fernandes age 41 years, Christian, male, native of Goa. Tubercular leprosy. Ill for 3 years. No family history of leprosy.

Has been under treatment since 11th February, 1908. Has had 5 injections of B 1 and 23 injections of B 2.

The tubercles have nearly disappeared from the ears and face. He does not feel the tingling sensation that he used to feel before he started the injections in the extremites, and he has slightly regained sensation in the feet and right arm. His general health has been very good and he has kept an uniform weight of 4 maunds during the treatment.

CASE No. V.

Manoel Soothnyal, age 50 years, Christian, male, native of Bassein. Anæsthetic leprosy. Ill for 10 years. No family history of leprosy.

Has been under treatment since 11th February 1908. Has had 36 injections of B 1.

He has regained his sensation over the body which he had lost and also on the extremities except on the dorsal surfaces of the hands and feet. The ulcers on the feet which he had since the disease started have all healed. His general health has been very good, and he has kept a varying weight of 3 maunds 15 lbs. to 3 maunds 21 lbs. during the treatment.

CASE No. VI.

Augustinho de Souza, age 42 years, Christian, male, native of Goa. Anæsthetic leprosy. Ill for 5 years. No family history of leprosy.

Has been under treatment since 11th February 1908. Has had 36 injections of B 1.

The anæsthetic patches that he had on the upper half of the body have all disappeared and he has regained his sensation. The loss of sensation on the extremities is slightly less. The ulcers on the feet have all healed up except one. He gets better sleep at night now owing to the tingling sensation that he felt at night having disappeared. He keeps good general health which he did not before. Has maintained a weight of between 4 maunds and 4 maunds 4 lbs. during the treatment.

CASE No. VII.

Pedro Luis de Souza, age 20 years, Christian, male, native of Africa. Tubercular leprosy. Ill for 2 years. Mother was a leper.

Has been under treatment since 10th April 1908. Has had 2 injections of B 1 and 19 injections of B 2.

The swelling of the feet, of which he complained most, has disappeared, most probably owing to the tubercles from the lower extremity having disappeared. The tubercles from the upper extremity have also gone away likewise, but the tubercles on the face and ears have slightly increased although the old ones seem to

decrease in some places. The ulcers on the left knee joint and right foot have healed up and he enjoys far better general health than he did before. Has maintained a weight of between 3 maunds 9 lbs. and 3 maunds 21 lbs.

CASE No. VIII.

Luis Mariano Fernandes, age 35 years, Christian, male, native of Goa. Anæsthetic leprosy. Ill for 12 years. No family history of leprosy.

The most relief the patient declares that he finds is that he gets sleep at night due to the peculiar tingling sensation (as if needles were being passed through him) in his body having disappeared. He used to be a nuisance to the other patients on account of groaning as if in pain every night throughout. He has slightly regained his sensation over the anæsthetic patches on his body. The colour of these patches also is gradually returning to the colour of the surrounding normal skin. The œdema of the left foot has disappeared owing to the ulcer healing up nearly. Keeps good general health, and has maintained a weight of between 3 maunds 13 lbs. and 3 maunds 15 lbs. during the treatment.

CASE No. IX.

Jeronio da Costa, age 25 years, Christian, male, native of Bassein. Tubercular leprosy. Ill for 6 years. No family history of leprosy.

Has been under treatment since 2nd April 1908. Has had 1 injection of B1 and 22 injections of B2.

The tubercles from the extremities and face are slightly less and the patient feels very lively. Keeps very good general health, and has kept an uniform weight of 3½ maunds during the treatment.

CASE No. X.

John Gregorio Sales, age 46 years, Christian, male, native of Goa. Anæsthetic leprosy. Ill for 17 years. No family history of leprosy.

Has been under treatment since 4th April 1908. Has had 34 injections of B 1.

The tingling sensation in the body has left him. The loss of sensation in the extremities is just the same. The ulcers on the feet are healing up gradually. Keeps good general health, and has maintained an uniform weight of 3 maunds 21 lbs. during the course of treatment.

CASE No. XI.

Govind Ganoo, age 35 years, Hindu, male, native of Ratnagiri. Tubercular leprosy. Ill for 8 years. No family history of leprosy.

Has been under treatment since 7th April 1908. Has had one injection of Nastin B1 and 19 injections of Nastin B2.

The tubercles on the face and extremities are just the same. The only improvement that he finds is that the tingling sensation that he felt in the extremities has disappeared. The loss of sensation of the left ulnar nerve is just the same. General health has been good and he has maintained a weight of between 4 maunds and 4 maunds 7 lbs. during the course of treatment.

CASE No. XII.

Sakaram Tanoo, age 39 years, Hindu, male, native of Malwan. Tubercular leprosy. Ill for 6 years. No family history of leprosy.

Has been under treatment since 2nd May 1908. Has had 12 injections of B 1 and 14 injections of B 2.

The tubercles on the face and extremities are the same, only the tingling sensation has left him. General health good. His weight during the treatment has decreased from 3 maunds 21 lbs. to 3 maunds 14 lbs., that is, he has lost 7 lbs. during the treatment.

CASE No. XIII.

Bagia Bapoo, age 36 years, Hindu, male, native of Payne. Mixed leprosy. Ill for 10 years.

Has been under treatment since 2nd May 1908. Has had 12 injections of B1 and 11 injections of Nastin B2.

The only improvement that he finds is that the tingling sensation has left him altogether, otherwise he is just the same as when he started the injections. Keeps good general health, and has maintained an uniform weight of 3 maunds 10 lbs. to 3 maunds 7 lbs.

CASE No. XIV.

Yenco Dowlatia, age 35 years, Hindu, female, native of Hernai. Mother, maternal uncle and brother had leprosy. Anæsthetic leprosy. Ill for 7 years.

Has been under treatment since 7th April 1908. Has had 31 injections of Nastin B 1.

Finds no improvement, but she is not worse. Keeps good general health. Has maintained a weight of between 3 maunds 11½ lbs. and 3 maunds 14 lbs.

CASE No. XV.

Yeomuna Baboo, age 38 years, Hindu, female, native of Malwan. Husband's brother had leprosy. Anæsthetic leprosy. Ill for 8 years.

Has been under treatment since 8th June 1908. Has had 27 injections of Nastin B 1.

She is just the same as when she started the injections except that she enjoys better general health than what she did before. The anæsthesia over the body and the ulcer on the left foot are just the same. Has kept an uniform weight of 3 maunds 14lbs.

CASE No. XVI.

Ratnia Govind, age 35 years, Hindu, male, native of Ratnagiri. Tubercular leprosy. Ill for 5 years. No family history of leprosy.

Has been under treatment since 23rd May 1908. Has had 8 injections of B 1 and 15 injections of B 2.

The tingling sensation and swelling of the feet have disappeared. The tubercles from the face and ears are slightly decreased. General health good and keeps an uniform weight of 4 maunds 4lbs.

CASE No. XVII.

Hari Malia, age 30 years, Hindu, male, native of Uran. Tubercular leprosy. Ill for 8 years. No family history of leprosy.

Has been under treatment since 8th June 1908. Has had 7 injections of B 1 and 17 injections of B 2.

The tingling sensation from the lower extremities has disappeared. He gets sleep at night now, which he did not before due to pain. The tubercles on the face and extremities are much less. Keeps good general health and an uniform weight of 3 maunds 21 lbs.

CASE No. XVIII.

Santanna Rama, age 12 years, Christian, male, native of Bassein. Anæsthetic leprosy. Ill for 3 years. Mother had leprosy.

Has been under treatment since 11th July 1908. Has had 23 injections of Nastin B 1.

Has regained his sensation over the anæsthetic patches on his body, and slightly in the extremities. The colour of the patches also is gradually coming to that of the normal skin around. The ulcer of the right foot has healed up. Keeps good general health and an uniform weight of 2 maunds.

CASE No. XIX.

Rosa Fernandes, age 25 years, Christian, female, native of Bassein, Tubercular leprosy. Ill for 3 years. No family history of leprosy.

Has been under treatment since 11th August 1908. Has had 21 injections of B 0.

The swelling of the face has disappeared and tubercles have appeared which she had not before. Though the tubercles on the hands are much less new tubercles have appeared on the thighs. The pain that she used to feel in the knee joint has disappeared completely. Keeps good general health, and her weight has increased from 2 maunds 18lbs. to 3 maunds 7 lbs.

CASE No. XX.

Bheewa Ganoo, age 26 years, Hindu, male, native of Ratnagiri. Tubercular leprosy. Ill for 2 years. No family history of leprosy.

Has been under treatment since 11th August 1908. Has had 1 injection of Nastin B 1 and 16 injections of Nastin B 2.

The tingling sensation in the extremities is very much less. The sanguineons discharge that he had for nearly 6 months from the nose before he started the injections has entirely stopped. The tubercles on the face and extremities are just the same. Keeps good general health and a uniform weight of 4 maunds 7 lbs.

CASE No. XXI.

Manoel Rego, age 38 years, Christian, male, native of Goa. Tubercular leprosy. Ill for 20 years. No family history of leprosy; both eyes attacked with the disease and has very little sight.

Has been under treatment since 20th August 1908. Has had 17 injections of B 0.

The frequent exacerbations of the disease have now stopped since the treatment. Slight disappearance of the tubercles in some places. The disease in this patient first showed itself in the left testicle which got tubercular and gradually became hard and big. Now since the treatment the size of the testicle has decreased, and it has become softer. The tired feeling and thirst that he felt before has disappeared. Enjoys good general health and has increased in weight from 2 maunds 26 lbs. to 3 maunds 10 lbs.

CASE No. XXII.

J. P. Lafranais, age 37 years, Christian, male, native of Cochin. Tubercular leprosy. Ill for 20 years. Brother was a leper; one eye completely gone, the other eye partially affected.

Has been under treatment off and on since 7th April 1908. Has had 2 injections of Nastin B 1 and 13 injections of Nastin B 0.

He felt slightly improved in his general health in the beginning, then he got cloudiness of the eyesight, and he was then injected with B 0. After some time a rash appeared on the body and he felt a severe itching sensation, after which the injections were stopped. He kept a uniform weight of 4 maunds.

CASE No. XXIII.

Abdulla Kassum, age 50 years, Mahomedan, male, native of Janjira. Anæsthetic leprosy. Ill for 15 years. Brother was a leper.

Had been under treatment since 4th April 1908. Has had 10 injections of Nastin B 1 and 9 injections of Nastin B 0.

No improvement. The loss of sensation is just the same. The eyesight became slightly cloudy and the injections have been stopped.

The other cases have been under treatment for a very short period and they are neither worse nor better.

The time is too short to come to any conclusion, as far as my clinical experience goes, of this treatment.

For the sake of experiment I could not choose my cases, but had to be satisfied with those who offered themselves voluntarily for the treatment.

You will see from the foregoing cases that the duration of the disease is long, and consequently the improvement shown is very slow and sometimes nil. In some cases improvement manifested itself after a dozen injections or so, and then the patients have remained stationary as regards the disease.

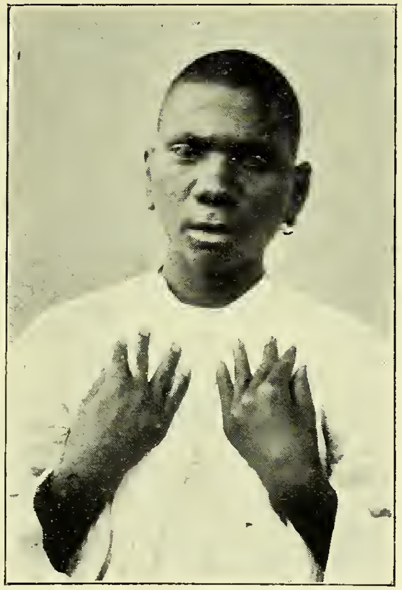
Most of the patients complained of an itchy sensation in the beginning of the treatment, but, after a time, it subsided, except in cases No. I and No. XXII, in whom it became so unbearable as to prevent sleep at night.

It is a curious fact among Christian patients that before they put themselves under Nastin treatment whenever they ate pork flesh it was followed by a rise of temperature and inflammation of the tubercles and glands. Since they have been under Nastin treatment they can eat pork flesh with impunity and no such untoward symptoms follow. I do not know whether this fact will be of any significance for a bacteriological purpose, I mean as regards the culture of the lepræ bacilli.

When I first started the injections with B1 many of the patients began complaining of the eyesight becoming cloudy and the agents then sent me B 0, after which that complaint disappeared, except in two cases No. XXII and No. XXIII, which did not improve

TREATMENT OF LEPROSY WITH RONTGEN RAYS.

JEROMO D'COSTA.

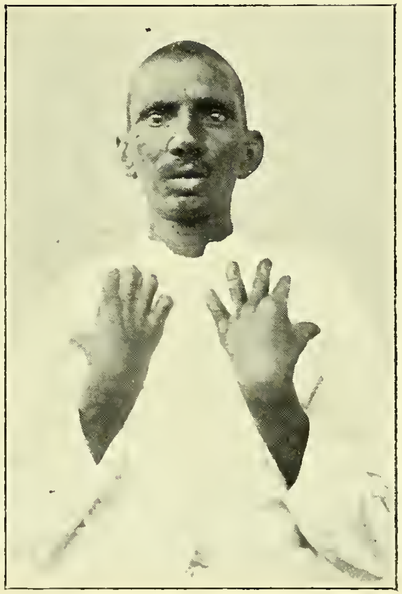


JEROMO D'COSTA.—*February* 1909.

D. M. FERNANDES.

D. M. FERNANDES.—*February* 1909.

CARIDADE FERNANDES.



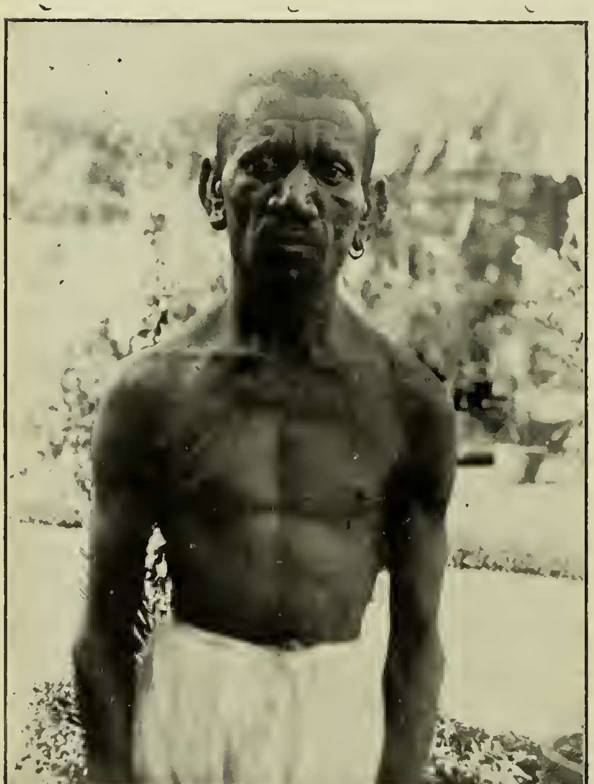
CARIDADE FERNANDES.—*February* 1909.

DOMINGO COLLACO.

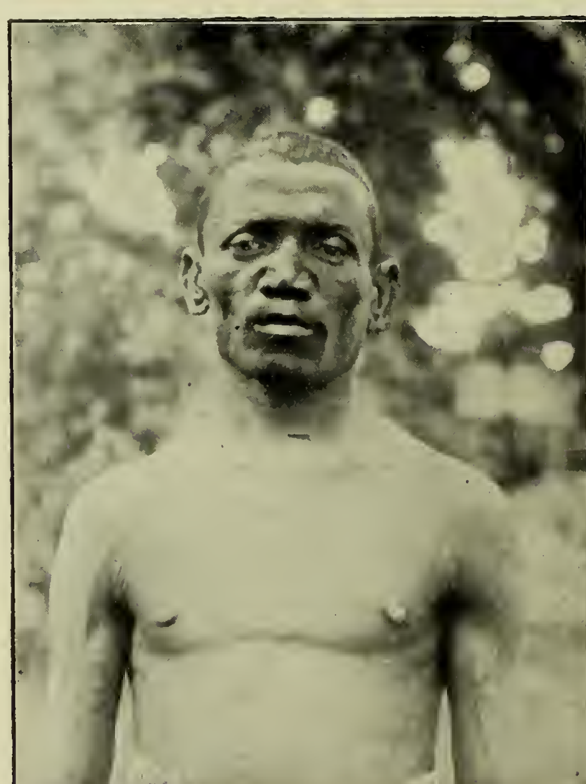
DOMINGO COLLACO.—*February* 1909.

M—B—*December* 1904.
At the commencement of the treatment.

M—B—*February* 1907.
After 2 years' treatment : Face and both ears show considerable improvement ; Right ear slightly smaller than the left.



S—T—*December* 1904.
At the commencement of the treatment.



S—T—*February* 1907.
After 2 years' treatment : Right ear shrivelled ; Face shows marked improvement.

until we had given up the injections. In the above two cases I even gave injections of Ketyu.

The most remarkable effects of the treatment are that mostly all the patients that were suffering from a tingling sensation positively declare the disappearance of that sypmtom so that they get better sleep at night. Another effect that is seen is the healing up of old chronic ulcers which were at times intractable to ordinary treatment.

Their general health has been good since they started the treatment and they feel livelier, more cheerful, stronger and more active for work than what they felt before they started the treatment.

You will find as regards their weight they either have kept a uniform weight during the treatment or gained weight except in 2 cases.

In those cases, in which the tubercles have increased, I do not think it is the effect of Nastin, but I think it is the course of the disease, which I daresay will subside in time if the injections are continued.

The other day when the patients were asked that those who felt no benefit should forego the treatment, all declared positively that they wished to continue it as they felt themselves better in their general health, and those that showed no objective signs of improvement said that they hoped in time to be improved like the others.

Better results perhaps will be shown as the treatment is continued and as the patients come under the influence of Nastin, but at the same time I must say, that when I started the injections too rapidly, I mean every 5 days, especially in cases of B 2 I found that reactions began to follow and I had to be satisfied with injecting every 8 days. Too strong a quality of Nastin, and too short a period between injections, I find hinder the progress of recovery. Those patients showed most improvement who were not completely run down in health before they started the treatment, while others took a longer time.

This being a charitable institution the food cannot be expected to be of the first quality as the institution cannot afford it. The patients undergoing the Nastin treatment have to live the same life as the other non-Nastin patients. All this must hinder the progress of recovery as they have to breathe the foul and contaminated air of the overcrowded wards.

The injections will have to be continued in those cases which show an improvement till they either get cured or worse and then whether the treatment is a success or failure will be known.

TREATMENT OF LEPROSY WITH RÖNTGEN RAYS.

By D. A. TURKHUD, M.B., C.M. (Edin.).

TREATMENT OF LEPROSY WITH X-RAYS.

In this paper a short attempt is made at placing before the Profession the result of two years' experiments conducted at the Acworth Leper Asylum, Matunga, Bombay, on the treatment of Leprosy with Röntgen Rays.

The apparatus used was a 10″ Cox Coil worked with a Mackenzie-Davidson interruptor, and actuated by means of storage batteries.

The treatment was commenced on the 29th November 1904, and at first 32 cases were selected for trial both of the nodular as well as the anæsthetic type.

In the nodular cases the Rays were applied in the majority of cases to the face, and upper part of the chest, and, when applied to the face, the precaution of protecting the eyes with lead sheets was invariably taken.

In the first experiments, the time of exposure was 3 minutes, and the distance between the focal tube and the part exposed, generally about 6 inches.

A more prolonged exposure was purposely avoided as it was not known how the unhealthy skin of leprous patients would withstand the action of the Rays.

The following are some of the subjective sensations felt by the patients after an application. Some complained only of a sensation of heat in the part exposed. In others there was a sensation of pricking or formication. Some complained of headache, while others of a deep-seated orbital pain.

The reactionary vascular erythema seen in fair complexions after an exposure to X-Rays could not be noticed in the dark skin, but there can be no doubt that all the subjective phenomena mentioned above were due to an increased determination of the blood in the parts exposed.

A very marked result of the application of the Rays was darkening of the skin, probably due to a prolification of the natural pigment of the cutis. This phenomenon is probably akin to the bronzing of the skin produced by the proliferation of melanin under the action of the rays of the sun.

The effect of the X-Rays on the leprous nodules and other hypertrophies was a preliminary slight enlargement followed by a gradual atrophy, as evidenced first by a flattening, and then a subsidence, followed by shrivelling and wrinkling of the skin—signs of atrophy of the cutis.

The exposures in anæsthetic cases were made on the anæsthetic areas, but the effect in these cases was not so marked.

In one case, however, of a large patch of anæsthesia, sensation seemed to return after only a few exposures. In another case all the elevations from leprous infiltration of the skin and discoloration patches subsided as the result of the treatment.

There was one case of X-Ray dermatitis of the nose, which rapidly subsided under the application of Unguentum Zinci Oxidi.

Out of the 32 cases selected originally for treatment four died of inter-current diseases and four left treatment. The remaining twenty-four showed the following results:—

7	showed	slight improvement.
7	,,	marked improvement.
5	,,	considerable improvement.
5	,,	no improvement.
Total 24		

order to study their effects on the general condition of the patients.

Out of the cases treated during 1905 those that showed no improvement, and 5 others expressed unwillingness to go on with further treatment. Only 14 patients, therefore, continued the treatment.

The treatment of the separate series of cases by means of High Frequency Currents, in the form of auto-condensation, had to be abandoned, as this mode of electrical application appeared to throw a considerable strain on the accumulators, which frequently got out of order, and gave much trouble.

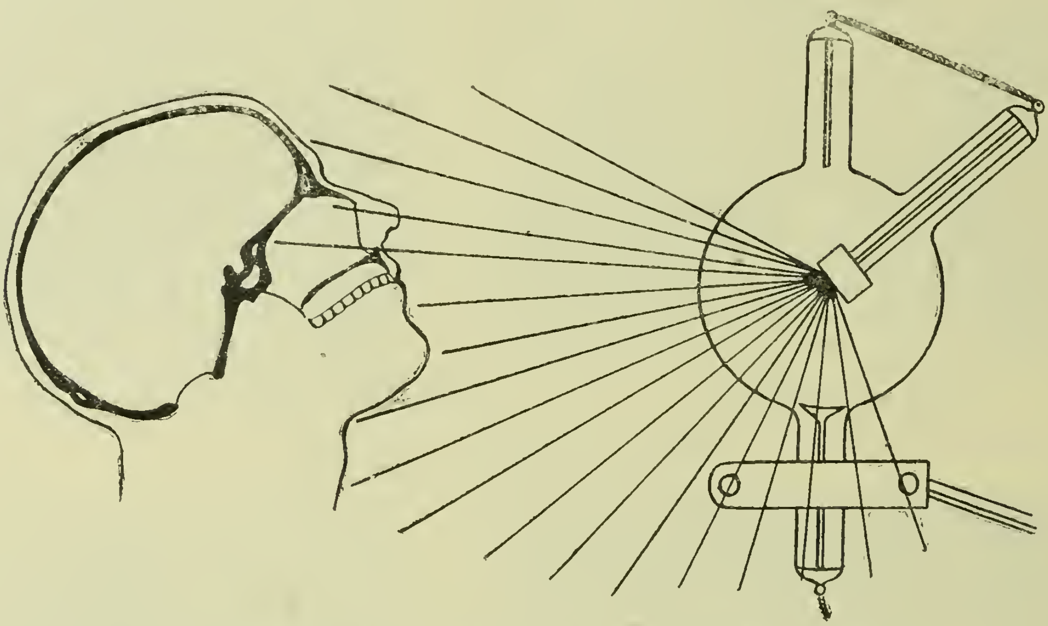


Diagram to show the position of the head recommended for the application of the X-Rays.

The results of the first year's treatment were submitted to a special committee composed of:—

1. Col. H. P. Dimmock, M.D., I.M.S., Principal of the Grant Medical College, Bombay.
2. Captain W. G. Liston, M.D., I.M.S., of the Bombay Bacteriological Laboratory, and
3. Khan Bahadur Dr. N. H. Choksy, M.D., Special Assistant Health Officer, and formerly Medical Officer-in-charge of the Acworth Leper Asylum.

The committee met on the 14th January, 1906, examined all the cases that were undergoing treatment, and made the following report:—

"The committee inspected 24 patients and compared the result as shown by the photographs and the present conditions, total and general, in each case.

"The committee are of opinion that the treatment has resulted in decided improvement in the majority of cases and consider that it should be continued for a further period of one year."

The committee further recommended that in addition to the treatment by the X-Rays a separate series of cases should be treated with High Frequency Currents in

In the first year of treatment in the majority of the cases the whole of the face with the upper part of the chest was subjected to the action of the Rays, the eyes being suitably protected, the time of exposure being 3 minutes.

In the second year of treatment, 1906-07, Col. Bannerman, I.M.S., Director of the Bombay Bacteriological Laboratory, suggested that one ear only should be exposed to the Rays, and this suggestion was adopted as it had the advantage that the local effect of the treatment could be very readily observed by simply comparing the ear subjected to the rays with the untreated organ on the opposite side. In every case the right ear was selected for treatment, the surrounding parts being protected with lead sheeting, and the time of exposure was increased, at first to 5, and later on to 7 minutes.

After a year's treatment the local effect produced by the Rays was well marked. The exposed ear, in the majority of the cases treated, became more or less smaller in size, and darker than the opposite ear. The atrophy of the organ was also accompanied with atrophy of the cutis as shown by the wrinkled appearance of the skin.

This atrophy is a preliminary stage towards cure, for it is similar to the condition produced by the absorption of leprous infiltration which, in a few instances, is seen to occur spontaneously from unknown causes.

The effect of the treatment on the general condition of the patient, however, was not so apparent, and the improvement, so marked in some of the cases of the previous year, did not appear to have gone on. But it must be remembered that whereas during the second year of the treatment, only the right external ear was exposed to the action of the X-Rays, the whole of the face, the facial bones, and the upper part of the chest were subjected to their action during the year previous.

The reasons why the effects of the second year's treatment were purely local, and not general as in the first year of treatment, are in my opinion as follows:—

First because the action of the rays was confined only to the ear treated as the rays could not penetrate further on account of the lead sheet used.

And secondly because they were unable to reach the nasal cavity in which the lesion of leprosy lies.

There was not a single case of X-rays dermatitis during the second year.

These cases were again shown to a special committee composed of:—

1. Col. H. P. Dimmock, M.D., I.M.S.
2. Khan Bahadur Dr. N. H. Choksy, M.D., and
3. Capt. W. H. Dickinson, I.M.S.

who reported as follows:—

"The committee visited the asylum on the 23rd April, 1907, and inspected the patients who had remained under treatment since last year, and compared the result of the X-Ray treatment as shown in the photographs through the last two years and the appearances of the patients."

"The treatment during the last year has been entirely confined to the local treatment of the right ear. The committee observe that the local conditions show decided improvements; in most of the cases the ear is smaller and shrivelled, in some, the general condition also shows improvement, but in the majority there is no marked general improvement."

The accompanying photographs give an idea of the results of two years' treatment; the improvement in the general appearance, and the marked local effect produced by the treatment are well seen in both these cases, which it will be noticed were by no means of a mild type.

Researches have proved that X-Rays are more effective when directed over the cancellous portions of bones and that they possess a special selective resolvent action on morbid tissues.

Holzknecht states that the cure of an infective process by the X-Rays is not due to any bactericidal action of the rays since the bactericidal dose is much greater than the curative dose.

Schwartz and Neisser point out that there is a resemblance between the action of the X-Rays and that of Tuberculin, and McCulloch believes that the mechanism of the therapeutics of the X-Rays rests upon the induction of an auto-vaccination subsequent to the resolvent action of the rays which render the vaccine accessible to the blood stream. In tuberculosis the opsonic index can also be raised by exposure to X-Rays.

All these observations have been made in connection with tuberculosis; but bacillus tuberculosus, and B. Lepræ are so much identical that they might be utilized in connection with Leprosy.

In an abstract on the treatment of Leprosy with X-Rays, Dr. Wilkinson, of the San Lazaro Hospital, Manila, states that, when a local lesion of leprosy is treated with X-Rays, the organisms there localized are killed and the bodies are absorbed into the system, thereby producing an immunity of the system against the living organisms.

Researches have also proved that the penetrability of the X-Rays is increased by the use of Strontium Salicylate.

In view of these researches I would suggest that a further trial should be given to the treatment of Leprosy with X-Rays conducted on the following lines:—

The face and if necessary the upper part of the chest should be painted over with a solution of Strontium Salicylate (strength 26 grains per ounce) heated to 100° F. before using; or the solution may be injected into the infiltrated parts. The X-Rays should then be turned on for about 10 minutes.

The exposure to the rays should be made in such a way that the nasal cavity in which the morbid process of leprosy is specially active should get a large proportion of the rays. This can be secured by having the head of the patient slightly thrown back as shown in the accompanying diagram.

DISCUSSION.

Dr. Arthur Powell.—Is the X-Ray treatment still continued at the Asylum?

Dr. Rodrigues.—No.

Dr. Powell.—Why?

Dr. Rodrigues.—The results did not appear sufficiently favorable.

STREPTOTHRICOSIS

With Special Reference to the Etiology and Classification of Mycetoma.*

By W. E. MUSGRAVE and M. T. CLEGG.

INTRODUCTION.

Before entering on a study of the etiology of mycetoma, it is necessary to define the disease. This is exceedingly difficult, either from a clinical or an etiologic standpoint.

Formerly the diagnosis was based upon a clinical picture, the essentials of which were a chronically enlarged foot with sinuses from which were discharged small granules of various colors and consistency, accompanied by a peculiar, oily degeneration of the tissues. Further classification was made principally upon the color of the granules; black, ochroid, white, red and mixed varieties being recognized. However, when bacteriologic studies began to show the multiplicity of the organisms concerned in the production of Madura foot it became necessary either to consider it a clinical entity of multiple etiology or to attempt an etiologic classification. This was made still more imperative by the discovery that the organisms causing this symptom complex were found also producing lesions in other parts of the body. A number of authors have continued to use a clinical classification, while others have attempted to give one based upon etiologic findings. The result is great confusion in the nomenclature of the disease.

As a pre-requisite to an etiologic classification and definition of mycetoma it is necessary first to know and to be able to classify the etiologic factors concerned. So far this has not been done satisfactorily. The botanists are hopelessly confused in their grouping of the organisms and, in consequence, medical men have been unable properly to identify them. In the first place, authorities differ as to where the group of organisms belongs in the vegetable kingdom, some placing it among the bacteria and others higher up among the fungi. Practically all the latest writers upon the subject agree as to the great similarity between the various species of these organisms and the majority have placed them as species of a single genus, or as parts of two or even three closely allied genera. In order to establish a uniform and clear conception, and, after carefully studying all phases of the question, we have decided tentatively to accept *Streptothrix* Cohn 1875 as the generic name of the group of organisms under discussion.

The result of this decision is that the other names given to the tentative genus, such as *Actinomyces*, *Nocardia*, *Oöspora*, etc., become synonyms, the disease streptothricosis being limited to infection with parasites properly belonging to the genus, the various species of which will be considered presently.

Adopting such an interpretation, we have a fairly definite group of organisms with reasonably uniform pathologic and clinical manifestations, connected with other groups of closely related organisms giving somewhat similar manifestations. For example, the *Oidia* or *Blastomyces* on the one hand and the tubercle bacilli on the other, may somewhat closely resemble the *Streptothricæ* in their action in certain parts of the body.

Mycetoma may be defined and classified in one of three ways, if *Streptothrix* is accepted as the most available generic name.

(1) It may be considered as a clinical disease of multiple etiology (which may or may not be limited to *Streptothrix* infections); (2) the term may appropriately be made synonymous with streptothricosis, actinomycosis nocardiosis, etc.; (3) it may be made a clinical type (foot infection) by a *Streptothrix* (*Actinomyces* or *Nocardia*). Each of these classifications has something in its favor and also may be criticised.

The first would make diagnosis easy, for all forms of foot enlargement giving certain clinical manifestations regardless of the etiology, known or unknown, might be included, but it is open to the objection of not being definite and does not conform to our present methods of etiologic classification.

The second method has much in its favor and is practically adopted by Manson. The objections to it are that it adds a new significance to a term which does not clearly express the conditions and also adds a further synonym to a group of infections already rendered confusing by the number of its synonyms. The difficulty can more satisfactorily be met by the third method.

We have therefore decided to follow the third classification making mycetoma a *clinical* type or variety of streptothricosis—*Streptothricosis pedis*—and to define it as follows:

A disease consisting of a *Streptothrix* infection of the foot (*Streptothricosis pedis*, *Actinomycosis pedis*), characterized by a chronic course, swelling and deformity of the part, a peculiar, oily degeneration of the tissues with cavity and sinus formations and the discharge through the fistulous openings of mycotic aggregations containing the micro-organisms.

Mycetoma, with this definition, becomes so intimate a part of streptothricosis that a balanced conception of it can only be obtained by a study of the whole subject of streptothricosis and a classification of the organisms concerned.

For this reason, the scope of this paper has been enlarged to include a discussion in two parts of the whole subject of *Streptothrix* or *Nocardia* infections.

* Professor Musgrave kindly distributed about 400 copies of the full report, to which was appended a complete bibliography.

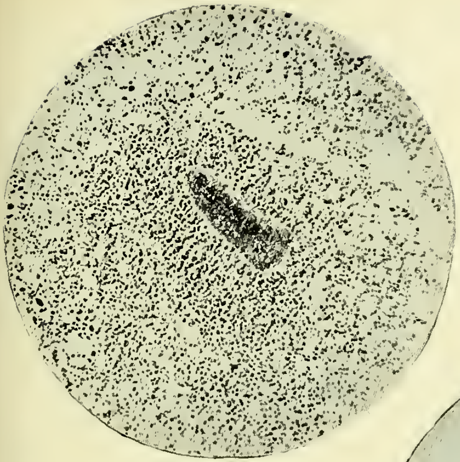


FIG. 1.

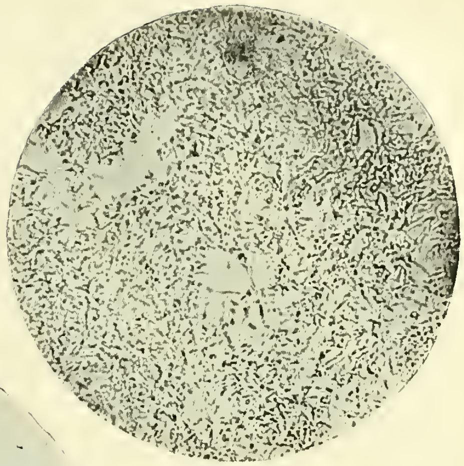


FIG. 2.

FIG. 5.

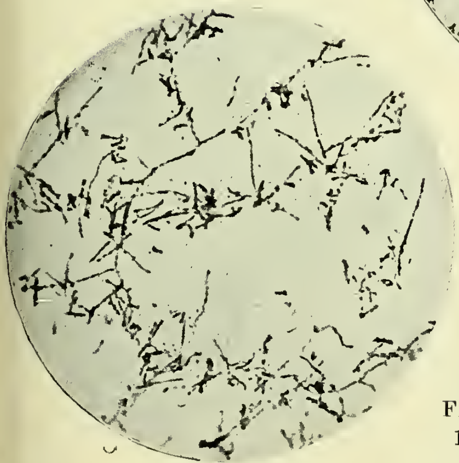


FIG. 3.

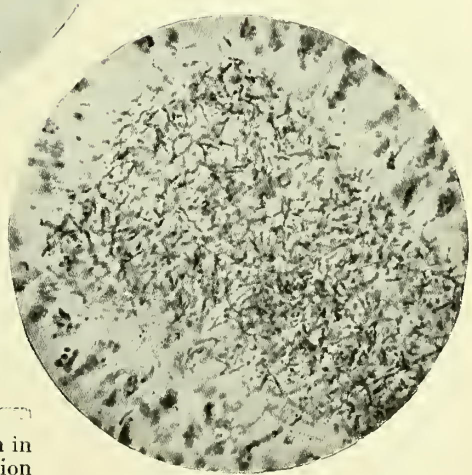


FIG. 4.

ILLUSTRATIONS.

FIG.

1. Section from experimental lesion in monkey produced by inoculation with culture of *S. Eppingeri*, × 60.
2. Unstained smear preparation from culture of *S. Eppingeri*, × 600.
3. Smear preparation from culture of *S. Eppingeri* stained by gentian violet, × 800.
4. Section from experimental lesion in mesentery of monkey produced by inoculation with culture of *S, Eppingeri*, × 600.
5. Smear preparation from culture of *S. Maduræ* stained by gentian violet, × 400.
6. Same as No. 5, × 600,
7. Section from experimental lesion in monkey produced by inoculation with culture of *S. Maduræ*, × 60.

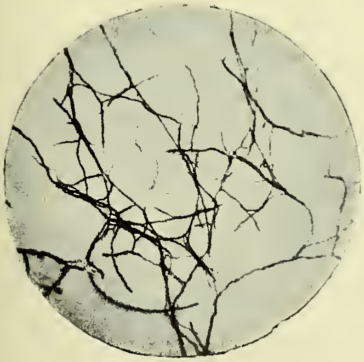


FIG. 6.

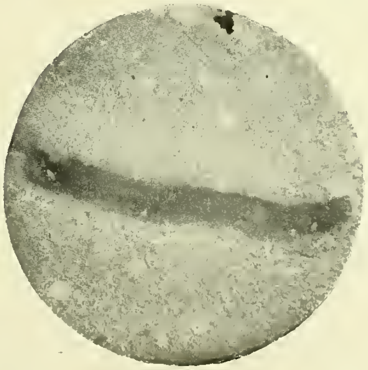


FIG. 7.

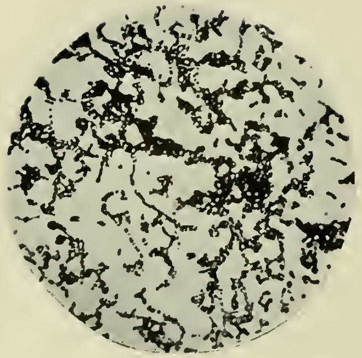


Fig. 8.

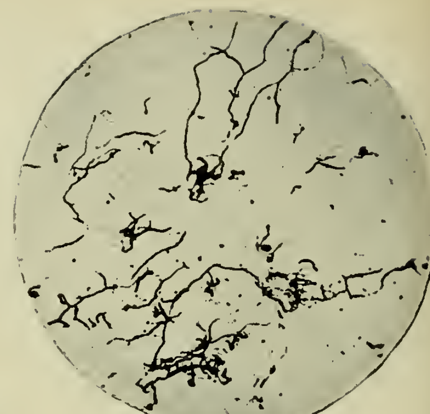


Fig. 10.

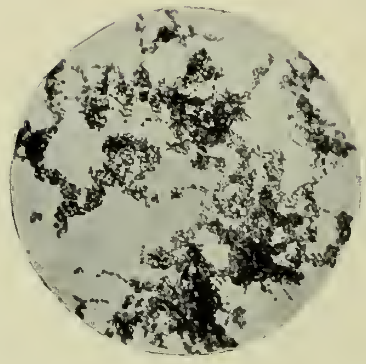


Fig. 9

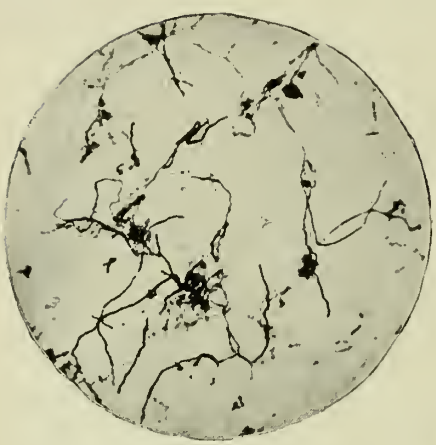


Fig. 11.

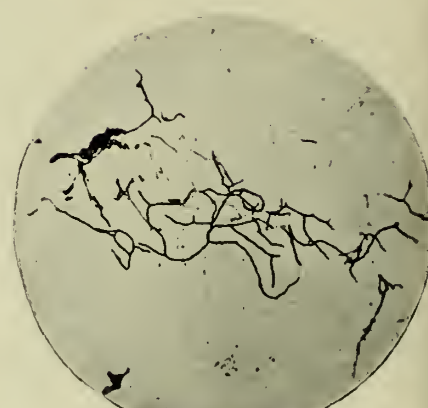


Fig 13.

Fig. 12.

Fig. 8. Smear preparation from culture of *S. Canis* stained by gentian violet, × 650.

9. Same as No. 8, × 650.

10. Smear preparation from culture of *S. Madura* (Strong's culture) stained by gentian violet, × 500.

11. Same as No. 10, × 700.

12. Same as No. 10 excepting that the prepartion is unstained, × 500.

13. Smear preparation from culture of *S. Actinomyces* (Pasteur Institute) stained by gentian violet, × 700.

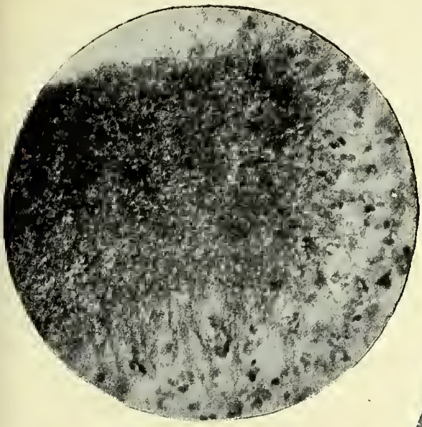


Fig. 14.

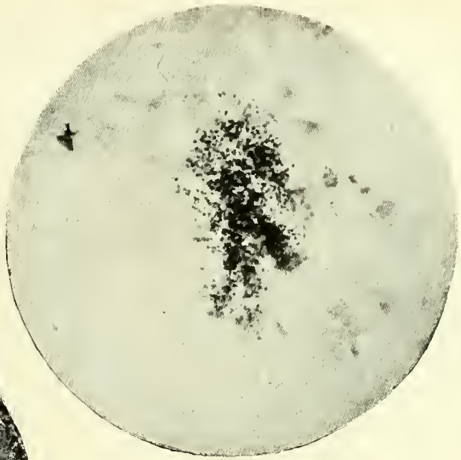


Fig. 16.

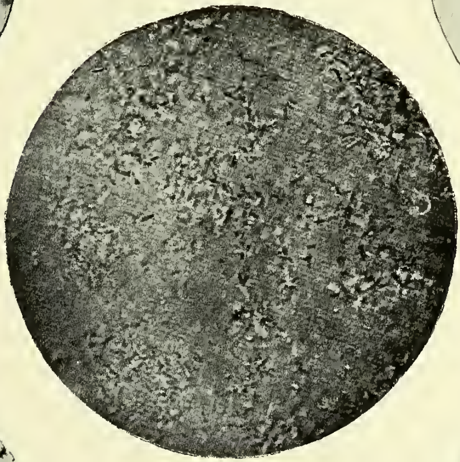


Fig. 15.

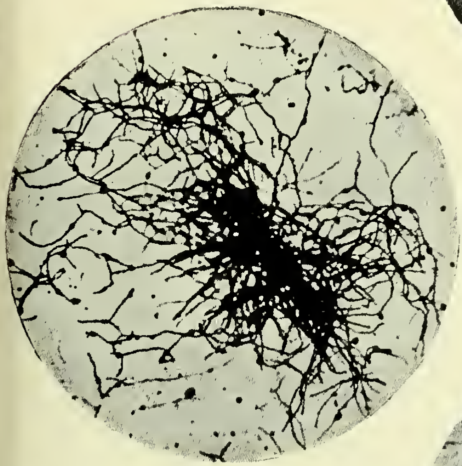


Fig. 17.

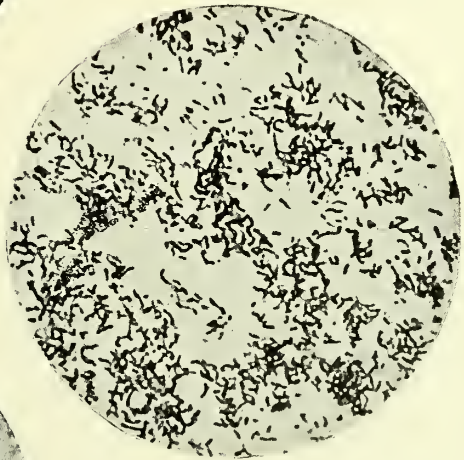


Fig. 19.

Fig. 18.

Fig. 14. Section from experimental lesion in monkey produced by inoculation with culture of *S. Maduræ.*

15. Smear preparation from culture of *S. Capræ* unstained, × 600.

16. Section from experimental lesion in monkey produced by inoculation with culture of *S. Actinomyces*, × 600.

17. Smear preparation from culture of *S. Actinomyces* stained by gentian violet, × 650.

18. Smear preparation from unstained specimen of *S. Actinomyces*, × 650.

19. Smear preparation from culture of *S. Capræ*, stained by gentian violet, ×650.

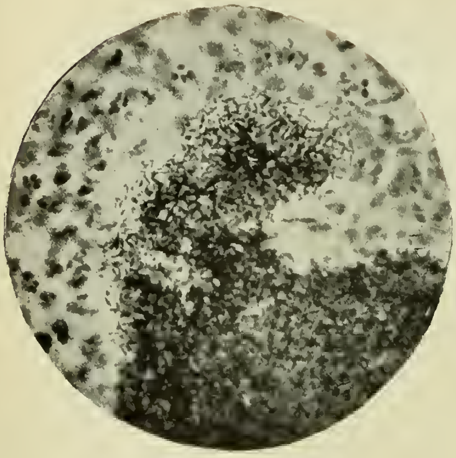


FIG. 20.

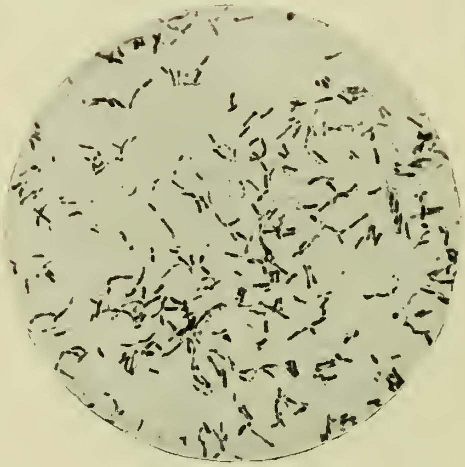


FIG. 21.

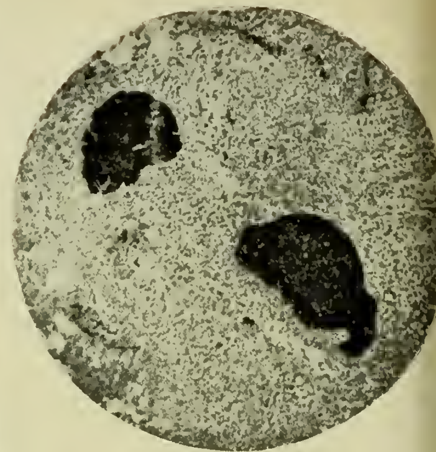


FIG. 22.

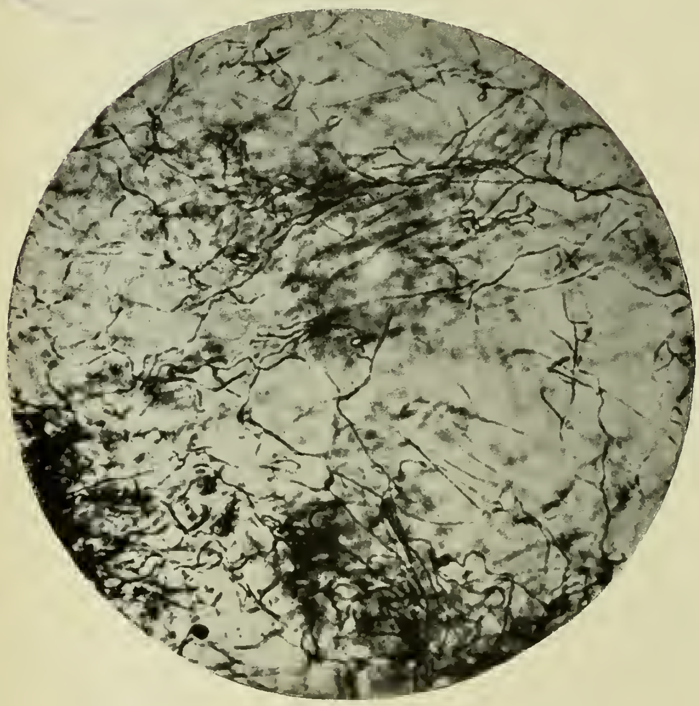


FIG. 23.

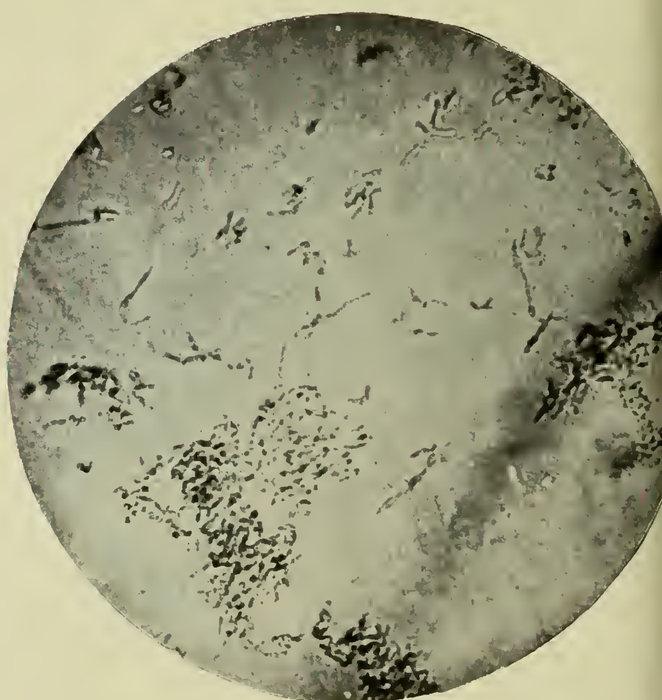


FIG 24.

FIG. 20 Section from experimental lesion from monkey produced by inoculation with culture of *S. Capræ*, × 600.

21. Smear preparation from culture of *S. Capræ*, stained by gentian violet, × 1100.

22. Section from experimental lesion in monkey produced by inoculation with culture of *S. Capræ*, × 60.

23. Smear preparation from culture of *S. Chalcea*, stained by gentian violet, × 850.

24. Smear preparation from cultures of *S. Nocardi*, stained by gentian violet, × 850.

PART I.

ORIGINAL WORK.

MATERIAL.

The material for this paper consists of the following cultures:

1. *S. Freeri* Musgrave & Clegg (Phil. Jour. of Science, Sec. B. 1907,—2,477.)

2. *S. maduræ* Vincent. (This culture was sent to us by Professor Foulerton who writes as follows concerning it: "This culture has been in my hands for the last ten years, it corresponds with Vincent's description of his organism, and is apparently of the same stock as that from which all the cultures in the London laboratories are derived.")

3. *S. maduræ* Vincent. (This culture was sent to us by Professor Binot of the Pasteur Institute in Paris.)

4. *S. maduræ* Vincent. (This organism was isolated by Dr. R. P. Strong from a case of the pink variety of mycetoma in India, and the culture has been given by him to us, for study.

5. *Streptothrix* of human actinomyces. (From Binot of the Pasteur Institute in Paris).

6. *Streptothrix* of "*farcin de bœuf*" "A". (From the late Professor Nocard through Binot).

7. *S. Nocardii.* (From Foulerton who writes that "this culture was given to me by Nocard some six years ago.")

8. *S. Eppingeri* "A".

9. *S. Eppingeri* "B". (Both of these cultures are from Foulerton who writes as follows: "'A' is a descendant of what I believe to have been Eppinger's original culture, 'B' a culture isolated by myself from a case which has not yet been published in detail. I have examined also a third culture of this species obtained by Dr. McDonald from a third case (*The Scottish Medical and Surgical Journal*, 1904). All three strains evidently belong to the same species.")

10. *S. capræ* Silberschmidt. (Received from Professor Silberschmidt of Zurich through Binot.)

11. *S. canis* Levy. (From Professor Levy of Strassburg through Binot.)

12. *S. chalcea* Foulerton. (Received from Foulerton who writes that this is a saprophytic species isolated by him from the air.)

The following cultures have also been received, but failed to develop on transplantation:

S. maduræ Vincent. (Furnished by Professor Vincent of the Val du Grace, Paris.)

S. maduræ. (From Legrain de Bougie through Binot.)

Streptothrix of bovine Actinomyces. (From Binot.)

Streptothrix of "*farcin de bœuf*" "N". (From the late Professor Nocard through Binot.)

Streptothrix of Eppinger ("A") and (KI). (From Binot.)

Streptothrix of Deci. (From Binot who writes regarding this culture that "it was isolated by Deci in the Argentine Republic from a human case resembling tuberculous meningitis." Binot further states in his letter that all the cultures which he has forwarded to us were received by him directly from their authors).

Streptothrix "32". (Received from Foulerton who writes that this organism was isolated by him from a kidney removed from the living patient by operation; the organism was demonstrable in sections of the kidney and was present in large quantity. It is briefly referred to as *S. hominis III* in the *Lancet* (1906), 1,970. "This organism resembles closely some of the apparently purely saprophytic species, and the infection in the case was probably primary in the lungs.")

Streptothrix isolated from a case of mycetoma by Dr. Chaterjee of India.

Dr. Homer Wright states, in reply to a letter regarding cultures of *Actinomyces* and his "*Hyphomycete*," that he no longer has cultures of these organisms.

A comparative study under conditions as nearly alike as possible has been made of all these strains, with due consideration of their morphology, biology, and pathogenic character. All of them, to obviate as much as possible any influence of long cultural environment were, where feasible, first passed through animals and the studies then made from the reclaimed cultures taken from the experimental lesions. All the cultural and other biologic properties have, so far as we have been able to do so, been studied under the same conditions in regard to media, temperature and generation from animal lesions. Our results and consequent descriptions show some variation from previous descriptions of some of these organisms, but in general the picture is very much as given by the original authors.

We have failed entirely to obtain a culture of the Wolf and Israel and Wright type of *Actinomyces*, but, because of the great importance of this organism in the discussion, we have, for comparative purposes, taken James Homer Wright's description of it from his classical monograph. We have also failed to secure a definite culture of Bostroem's *Actinomyces*, although the one sent by Professor Binot from the Pasteur Institute is probably of this species. However, in view of a possible mistake, we have used both the description given by Bostroem as well as the Pasteur Institute culture in our comparative work. The important characteristics of our cultures are shown in the following descriptions and are summarized in the attached table:—

No. 1 *Streptothrix Freeri.* This organism was isolated by us from a case of the ochroid variety of mycetoma and has already been fully described (Phil. Jour. of Science, Sec. B. (1907), 2, 477). It is identical with Eppinger's organism which will be discussed subsequently in this paper, and the name given by us in the first publication should fall as a synonym for *S. Eppingeri*, the latter having priority. Other described organisms of the group which are probably identical with this are those of Stokes, Aoyama and Miyamoto, MacCallum, Sabrezes and Rivière, and possibly several others.

No. 2. *Streptothrix maduræ.* This organism has been carefully described by Vincent, Foulerton, and others. A summary of its characteristics are given both in the text and table and in our first report and are again shown in the table attached to this paper. Our work with cultures of this species has been in the main confirmatory of the published results of others. We have worked with three cultures recieved respectively from Foulerton, Binot, and Strong. These strains are identical in every particular except that the one from Binot is less pathogenic for monkeys than either of the other two.

Morphologically this species gives very constant results. The colonies are made up of intertwining, long filaments which may, or may not, be radially placed at the periphery. There is true branching but no club formation in cultures and none in experimental lesions in monkeys up to fourteen days. The organism takes the usual aniline stains; it is Gram positive, but is neither acid nor alcohol-fast.

Culturally it is a facultative aërobe with strong oxygen requirements. It grows well in the incubator and at tropical room temperature. Positive transplants on artificial media are readily made, but some difficulty is often encountered in securing growth from experimental lesions. This difficulty is greatest when large quantities of the material are transferred to the media, probably because of an inhibiting material in the contents of the lesions. This hypothesis is supported by the fact that development is much more easily secured if the granules from the lesions are washed in sterile salt solution before transferring them to artificial media. Growth on satisfactory media becomes apparent in from two to four days; development gradually continues for several weeks, depending somewhat upon the quantity of medium present. The principal characteristics of growth on various types of media are shown in the table.

Pathogenesis: Several monkeys have been successfully infected with the Foulerton and Strong strains of this organism, but results with the one from the Pasteur Institute were all negative. Intra-abdominal inoculation has proved the most satisfactory and under similar conditions the character of the lesions produced varies but little. The lesions consist of nodular, tubercle-like processes in the omentum, abdominal wall, and contiguous tissues. These lesions break down and become surrounded by pockets and channels containing a peculiar pus-like material in which may be found the micro-organisms. (See also animal experiments).

No. 3. *Streptothrix maduræ.* (Pasteur Institute culture.) This is identical in all essentials with *S. Vincent* except that it is not pathogenic for monkeys. This may be due in part at least to its long cultivation on artificial media.

No. 4. *Streptothrix maduræ.* (Strong's culture.) This organism is identical with Vincent's species and its description has been included in the above.

No. 5. *Streptothrix actinomyces.* This culture was received from Professor Binot of the Pasteur Institute as human *Actinomyces*. It is quite different from the Wright type and it also appears to have slight distinctions from the Bostroem type of *Actinomyces.*

Morphologically it appears in the tissue as a fungus of the ray type, but without clubs in young experimental lesions. In colonies the cultures are dark, almost black in color, are made up of the branching filaments and transformation products, generally with radial arrangement of the terminals at the margins of the colonies.

The organism stains poorly by the usual laboratory methods; it is Gram positive and neither acid nor alcohol fast.

Culturally it is a facultative aërobe and grows on the majority of the usual media. In reclaiming cultures from experimental lesions this organism acts very much like *S. maduræ* mentioned above; however, if the colonies are first washed in distilled water and then transplanted to artificial media, growth takes place without difficulty.

This type, like the majority of the species examined, grows better in media containing sugar or glycerine. Pigment is produced in all media and the body of the medium is generally darkened to a considerable extent by the culture. The pigment varies from an ochre-yellow in ordinary agar to a dark, almost black, color in glycerine-agar and on potato.

The characteristics on various media are shown in the table.

Pathogenesis: This species is pathogenic for monkeys by intraperitoneal inoculation. It produces the usual actinomycotic lesion like those seen in the clinical disease in man and animals. The organisms are found in the broken down mass discharged from the sinuses.

No. 6. *Streptothrix* of *farcin du bœuf* "A," and

No. 7. *Streptothrix Nocardii.* These two strains are identical in all essential particulars and may therefore be described together under the correct name of *S. Nocardii.*

Nocard's original description of this organism was not very complete, but several other observers have studied his and other strains and a number of good descriptions have been given. Foulerton has devoted careful study to this species and our work is in general confirmatory of his description. We have already noted the principal characteristics of this organism in both the text and table in our first report and a summary is also shown in the table in this one. Photomicrographic illustrations of its appearance in cultures are also submitted.

Morphologically this parasite shows marked variation under different environment. In young cultures and early lesions the hyphal forms are prevalent and quite uniform in appearance, but in older cultures and in colonies from lesions, irregularities are encountered. Coccus and bacillus-like forms predominate, and very old cultures may almost have the appearance of mixed culture of bacteria. The filaments may or may not be radially placed at the periphery of the colonies. There is true branching, but no true clubs have been seen in cultures or in experimental lesions up to fifteen days of age. The Gram-Weigert method of staining gives good results and portions acid fast to the Ziehl-Neelsen-Gabbett method of staining are very numerous. The organism is also alcohol fast.

Culturally this species is a facultative aërobe. It grows

Cultural characteristics of various types of Streptothrix an

	Streptothrix Eppingeri from Foulerton "A."		Streptothrix Eppingeri from Foulerton "B."	
	Literature.	Our culture.	Literature.	Our culture.
Morphology	Mycelium with branching threads ending in spores of an elongated appearance and also showing clubbed ends.	Various forms noticed, depending upon the age of the culture and media, from small oval to long branching filaments. The diameter is fairly constant. No sheath observed and no clubs.	Foulerton has not yet published the details regarding this organism.	Similar to Eppinger's original culture.
Staining characteristics.	Cultures from 2 to 3 months old stained by Ziehl-Neelsen method show many portions which are acid-fast but not alcohol-fast.	Portions of filament acid-fast by Ziehl-Neelsen method; ovoid forms were decolorized; spore-like bodies and portions of mycelium are Gram-positive		Similar to Eppinger's original.
Growth on ordinary agar.	Small whitish colonies which coalesce into a thick adherent membrane with elevations and depressions of an orange color.	Growth appears after 2 days as smooth, adherent membrane at first a porcelain-white, later a delicate orange color; medium remains moist.		Do
Glycerine-agar.		Growth appears after 3 to 4 days, at first as small whitish colonies which gradually take on a delicate pink color. Later as the colonies develop they become umbilicated and coalesce forming a heaped up growth and producing an orange color.		Do
Maltose		Similar to glycerine-agar		
Potato	Growth appears after 48 hours as a granular layer, at first white, becoming yellow to brick-red. This is later covered by a fine, white, powdery efflorescence, culture resembling a sugar almond.	Growth appears after 48 hours as a granular layer at first white, becoming yellow to brick-red.		Growth appears after 48 hours, similar to Eppinger's original.
Bouillon	Growth appears after 24 hours as a small, white granule, forming a pellicle and adhering to sides of tube; some portions fall to the bottom. No pigmentation of medium.	Similar to literature		Similar to Eppinger's original.
Ascitic fluid		After 6 days very slight growth occurs on the surface of the medium; no pigment; no clubs.		Do
Pathogenicity for lower animals.	Not pathogenic for white mice. 3 rabbits inoculated subcutaneously recovered after developing temporary local swellings. 1 rabbit inoculated in anterior chamber of eye developed a nodule on the iris but no general infection. 1 rabbit inoculated intravenously and another in the kidney died on the fifth and seventh days respectively. Two guinea pigs inoculated intraperitoneally died on the eighteenth and twenty-fourth day.	Pathogenic for rabbits, guinea pigs and monkeys by intraperitoneal injection.		Do

	Streptothrix Nocardi.		Streptothrix maduræ from Strong.	
	Literature.	Our culture.	Literature.	Our culture.
Morphology	Long, thin, hyphæ twisted in masses showing many branching forms.	Many coccoid forms; short plumb filaments with short branching hyphæ occur, in young cultures; in older cultures ovoid forms predominate.	This organism has not previously been described.	Long, thin, filaments with true branching; no club forms.
Staining characteristics.	Cultures from 9 days to 3 months old stained by Ziehl-Neelsen method show many acid-fast portions; these are also alcohol-fast.	Cultures stained by Ziehl-Neelsen method show many acid-fast portions. The organism is Gram-positive.		Cultures stained by Ziehl-Neelsen method showed no acid-fast portions. Gram positive with irregular staining.
Growth on ordinary agar.	Small, white, irregular, round, opaque colonies which form an adherent, thick, wrinkled membrane-like lichen.	Small, white, irregular, round, opaque colonies; growth slow and not abundant on this medium; no pigment.		Grows very slowly and very little pigment is produced.
Glycerine-agar.		Appears after 3 days as discrete colonies; later the colonies coalesce and become heaped up, presenting a moist, mealy growth. This organism does not produce pigment.		Growth appears after 5 days as small pinkish-white colonies; later the colonies develop a heaped up growth and assume a wrinkled appearance with a deep-pink color.
Maltose		Similar to glycerine-agar		Similar to glycerine-agar
Potato	Growth appears after 48 hours as a buff-yellow granular growth; no pigmentation or erosion of medium.	Growth appears after 48 hours as a buff-yellow granular growth.		Growth appears after 3 days as small, pinkish-white colonies; these later develop a dark pink, raised growth.
Bouillon	Growth appears after 24 hours as a grayish, flocculent mass at the bottom of the tube.	Growth appears after 24 hours as a grayish, flocculent mass at the bottom of the tube; later a few grayish granules appear on the surface and in some instances puffball formation occurs at the bottom of the medium.		Growth appears after 5 days as a coherent mass at the bottom of the tube; surface growth rare.
Ascitic fluid		Very slight growth at the bottom of the tube; no pigment; no clubs.		Very slight growth; no pigment
Pathogenicity for lower animals.	Rabbits, dogs, cats, horses, and oxen are not affected by intraperitoneal or intravenous injections. In guinea pigs intraperitoneal or intravenous injections cause constantly, within 20 days, a miliary tuberculosis similar to that produced by ***Bacillus tuberculosis.***	Pathogenic for guinea pigs and monkeys by intraperitoneal injections.		Pathogenic for monkey by intraperitoneal injection.

	Streptothrix maduræ from Vincent.		Streptothrix maduræ from Foulerton.	
	Literature.	Our culture.	Literature.	Our cul
Morphology	Many twisted filaments showing true branching forms; the mycelium shows a ray-like growth at the periphery but no true club forms; some of the hyphæ show an enlargement along their courses.	Long, thin filaments with true branching; no club forms. These hyphæ may or may not be radially placed at the periphery of the granule.	Similar to *Streptothrix maduræ* of Vincent.	Similar to St *maduræ* of
Staining characteristics.	Culture 1 week old stained by Ziehl-Neelsen method showed no acid-fast portions.	Cultures stained by Ziehl-Neelsen method showed no acid-fast portions. Gram positive with irregular staining.	Do	Do
Growth on ordinary agar.	Small projecting, round, whitish-yellow colonies which slowly take on a rose color; they show umbilication in the centre and become confluent and adherent to the medium.	Grow very slowly on this medium; after 4 days small, whitish-yellow colonies develop.	Do	Do
Glycerine-agar.		Growth appears after 5 days as small, pinkish granules and later assumes a dark-pink color.		Similar to S *maduræ* with the that its p more del with a p ery.
Maltose	Growth appears after 8 days as small, discrete, yellowish-white colonies with waxy, wrinkled surface; later often developing pink pigment.	Similar to glycerine-agar		Similar to agar.
Potato		Growth appears after 3 days as small, pinkish-white colonies, which later develop a dark pink, round, granular growth.	Growth appears after 72 hours as a heaped-up, irregular mass of a creamy-yellowish white color, often showing patches of pink coloration; no pigmentation or erosion of medium.	Similar to S *maduræ* o
Bouillon	Growth appears as opaque-white, granular, more or less cohering colonies at the bottom of the tube; surface growth rare; no pigmentation of medium.	Similar to literature	Similar to *Streptothrix maduræ* of Vincent.	Do
Ascitic fluid		Very slight growth; no pigment.		Very slight pigment
Pathogenicity for lower animals.	The inoculation of cats, rabbits, guinea pigs, and mice produced nothing more than a small nodule at the site of injection and these disappeared (Vincent). Nocard carried out intraperitoneal, intravenous and subcutaneous inoculations of dogs, sheep, rabbits, guinea pigs, fowls and pigeons; his results were negative in every case.	Negative results in monkeys by intraperitoneal inoculation.	Similar to *Streptothrix maduræ* of Vincent.	Extensive produced peritone in monk contain organism similar in madu

Cultural characteristics of various types of Streptothrix and of Actinomyces.

[S. madu]ræ from Strong.	Streptothrix maduræ from Vincent.		Streptothrix maduræ from Foulerton.		Streptothrix capræ Silberschmidt.		Streptothrix canis, our culture.	Streptothrix chalea Foulerton, our culture.	Actinomyces from Pasteur Institute.		Streptothrix Freeri.	
Our culture.	Literature.	Our culture.	Literature.	Our culture.	Literature.	Our culture.			Literature.	Our culture.	Literature.	Our culture.
..., filaments with true branch- ... club forms.	Many twisted filaments showing true branching forms; the mycelium shows a ray-like growth at the periphery but no true club forms; some of the hyphæ show an enlargement along their courses.	Long, thin filaments with true branching; no club forms. These hyphæ may or may not be radially placed at the periphery of the granule.	Similar to *Streptothrix maduræ* of Vincent.	Similar to *Streptothrix maduræ* of Vincent.	Twisted, branching filaments which break off at the end into forms resembling bacilli or cocci. A few of the shorter forms show clubbed ends.	Short filaments resembling bacilli and many coccoid forms; occasionally longer filaments showing branching but no club forms.	Short, plump, filaments; many resembling bacilli; oval and coccoid forms.	Long, thin, filaments with branching hyphæ.	Ray Fungus consisting of a mass of mycelia, containing many spores in centre; branching forms present.	Radiating mycelium containing many spore-like bodies in centre; true branching occurs.	Similar to morphology described.	Long, branching filaments, 2 to 7 μ in diameter. Transverse segments are shown of various length from coccoid to 10 μ in length. Branching occurs as lateral hyphæ developing from the segments. The filaments have a definite wall. Spores have not been observed. Coccoid and club-like forms present in certain medium.
... stained by Ziehl-Neelsen showed no acid-fast portions. ...sitive with irregular staining.	Culture 1 week old stained by Ziehl-Neelsen method showed no acid-fast portions.	Cultures stained by Ziehl-Neelsen method showed no acid-fast portions. Gram positive with irregular staining.	Do	Do	Irregular staining	Cultures from 2 weeks to 2 months old stained by Ziehl-Neelsen method show many acid-fast portions, giving the organism the appearance of short, plump bacilli. Gram-positive, irregular staining.	Culture stained by Ziehl-Neelsen method shows many acid-fast portions. The organism is Gram-positive in portions, giving it the appearance of cocci and short bacilli.	No acid-fast portions by Ziehl-Neelsen method of staining Gram-positive for portions.	Culture stained by Ziehl-Neelsen method shows no acid fast portions. This organism stains well by the Gram method.	Culture stained by Ziehl-Neelsen method shows no acid-fast portions. This organism stains well by the Gram method.		Culture from 5 days to 2 months stained by Ziehl-Neelsen method show many acid-fast portions. The organism is Gram-positive.
...y slowly and very little pig... produced.	Small projecting, round, whitish-yellow colonies which slowly take on a rose color; they show umbilication in the centre and become confluent and adherent to the medium.	Grow very slowly on this medium; after 4 days small, whitish-yellow colonies develop.	Do	Do	In 2 or 3 days varicose, shrivelled, brownish-white colonies appear which form an adherent, brown, irregular membrane in from 8 to 15 days.	Growth appears in 2 or 3 days as small brownish colonies; medium remains moist; does not grow so well nor does it produce the pigment on this medium that it does on the sugar-containing media.	Grows as a smooth, glistening brownish-white colouy; does not grow so well on this medium as on sugar-containing media.	Grows as dark-brown, adherent membrane.	Small, opaque colonies which later show a white downy appearance and which coalesce into an adherent, wrinkled, lichen like membrane.	Small, opaque colonies which later become black and in time produces a bright yellow membrane; the medium becomes dark.	Similar to morphology described.	From 2 to 3 days' growth appears as smooth, glistening colonies which later coalesce and produce a delicate pink pigment; medium remains moist.
...pears after 5 days as small ...hite colonies; later the colo... ...elop a heaped up growth and ... wrinkled appearance with a ...k color.		Growth appears after 5 days as small, pinkish granules and later assumes a dark-pink color.		Similar to *Streptothrix maduræ* of Vincent with the exception that its pigment is a more delicate pink with a pale periphery.		Growth appears after 2 days as small, brownish-white colonies which later coalesce giving the growth a moist, mealy appearance with a light-brownish color.	Appears after 2 days as small brownish-white colonies. These later assume an ochre color. The colonies soon coalesce giving culture a moist, mealy appearance.	Grows as a dark-brown, adherent membrane.		Small, opaque colonies which later coalesce, developing a tough, black membrane; as growth proceeds a bright yellow pigment is produced on the surface of the membrane; the medium also takes on a dark color.		Growth after 3 to 4 days at first as small, whitish colonies; these gradually take on a delicate pink color; later as the colonies develop they become umbilicated and coalesce forming a heaped-up growth and produce a burnt ochre color.
...glycerine-agar	Growth appears after 8 days as small, discrete, yellowish-white colonies with waxy, wrinkled surface; later often developing pink pigment.	Similar to glycerine-agar		Similar to glycerine-agar.		Similar to glycerine-agar	Similar to glycerine-agar	Similar to glycerine-agar.		Similar to glycerine-agar		Similar to glycerine-agar.
...ears after 8 days as small, ...hite colonies; these later ... dark pink, raised growth.		Growth appears after 3 days as small, pinkish-white colonies, which later develop a dark pink, round, granular growth.	Growth appears after 72 hours as a heaped-up, irregular mass of a creamy-yellowish-white color, often showing patches of pink coloration; no pigmentation or erosion of medium.	Similar to *Streptothrix maduræ* of Vincent.	Colonies in 4 to 8 days which form a dry, brown, raised growth.	Appear after 3 days as slightly raised colonies which soon assume a light-brown color.	Growth appears after 2 to 4 days as slightly raised, white colonies; these later assume a light brown color.	Grows as a dark-brown adherent membrane.		Similar to glycerine-agar; medium becomes moist.		Do.
...ears after 5 days as a coher... ...at the bottom of the tube; ...owth rare.	Growth appears as opaque-white, granular, more or less cohering colonies at the bottom of the tube; surface growth rare; no pigmentation of medium.	Similar to literature	Similar to *Streptothrix maduræ* of Vincent.	Do	Colonies develop on surface as concave, fine, dry, pale disks which later form a surface membrane; fluid clear but a deposit forms in the bottom of the tube.	Colonies develop on the surface as fine, dry disks and later form a surface membrane; a deposit forms at the bottom of the tube; medium remains clear.	Growth occurs as a thin, white membrane on the surface of the medium; a deposit forms but the medium remains clear.	Growth from the planted material in the bottom of the tube; no surface growth.	Opaque, granular-like grape seeds, which coalesce to a loose, flaky sediment; no surface membrane forms.	Growth occurs in the bottom of the tube as a film containing many black granules; no growth on the surface of the medium.		Growth appears after 3 days as flat particles on the surface of the medium; these produce in time a delicate pink color; as growth proceeds a granular mass collects in the bottom of the tube; this mass more or less coherent.
...rowth; no pigment		Very slight growth; no pigment.		Very slight growth; no pigment.		Very slight growth; no pigment	Very slight growth; no pigment; no clubs	Very slight growth; no pigment; no clubs.		Very slight growth; no pigment; no clubs.		Very slight growth; no pigment; no clubs.
...or monkey by intraperito... ...ion.	The inoculation of cats, rabbits, guinea pigs, and mice produced nothing more than a small nodule at the site of injection and these disappeared (Vincent). Nocard carried out intraperitoneal, intravenous and subcutaneous inoculations of dogs, sheep, rabbits, guinea pigs, fowls and pigeons; his results were negative in every case.	Negative results in monkeys by intraperitoneal inoculation.	Similar to *Streptothrix maduræ* of Vincent.	Extensive lesions were produced by intraperitoneal injection in monkeys; lesions contain granules with organisms and are similar to those seen in madura foot.	Pathogenic for guinea pigs by subcutaneous and intraperitoneal injections.	Pathogenic for guinea pigs and monkeys by subcutaneous and intraperitoneal injections.	Intraperitoneal injections in monkeys produced numerous miliary tubercle-like bodies in the peritoneum and mesentery.	Negative		Intraperitoneal injection in monkeys produces extensive suppurative lesions containing many small, black granules.		Pathogenic for guinea pigs and monkeys by intraperitoneal injections.

on the majority of laboratory media at incubator or tropical room temperature ; development becomes apparent in from two to four days after inoculation. The difficulty of securing transplants from experimental lesions, mentioned in connection with *S. maduræ* does not obtain with this organism. The principal cultural characteristics on various media are shown in the table and may briefly be summarized as follows :

Small, white, irregular, round, raised, opaque colonies develop on *ordinary agar* after two to three days. Growth is slow and not abundant and no pigment is produced.

Glycerine-agar after three days shows discrete colonies which coalesce later and become heaped up, presenting a moist, meal-like growth. No pigment is produced.

On *potato* growth appears after 48 hours as a buff-yellow, granular, raised mass without pigmentation or erosion of this medium.

In *bouillon* growth appears after 48 hours as a grayish, flocculent mass at the bottom of the tube, later a few grayish granules appear on the surface of the medium and in some instances "puffball" formations occur at the bottom of the tube. The fluid remains clear.

In *ascitic fluid* a very slight growth slowly develops at the bottom of the tube.

In *litmus-milk* growth appears only at the bottom of the tube. The milk is not coagulated and its color is not changed.

Pathogenesis : This species is an exquisite tissue parasite for monkeys, and is pathogenic to a less extent for some other animals. Monkeys inoculated in the abdominal cavity and killed after five to fifteen days show characteristic lesions. In the majority of instances the early lesions are tubercle-like formations scattered through the mesentery and other tissues contiguous to the point of inoculation. In some cases pus pockets and channels are formed, surrounded by adhesions and containing granules made up of the micro-organisms in the pus-like material. Guinea pigs inoculated in a manner similar to the monkeys give parallel results.

No. 8. *Streptothrix Eppingeri* "A," and

No. 9. *S. Eppingeri* "B." These strains are identical in all essential particulars and may be described under the correct name of *S. Eppingeri.* This is one of the most important species of this group of organisms and has been well described several times. It has been isolated from anatomical lesions of such varying character as those from meningitis, by Eppinger and others, to Madura foot, as has been published in our first report. Foulerton has described this species and we have fully discussed its characteristics in our first report and summarized them in the table in this paper. Our work has demonstrated fully the identity of *S. Freeri* with this species and it is probable that several of the varieties described in the literature also must be classified with it. Its characteristics may be summarized as follows :

Morphologically a variety of forms exist varying from small, oval, coccus and bacillus-like bodies to long branching filaments, depending upon the lesion or the age of the culture and the media used. In tissues the branching filaments are not seen by the ordinary method of staining, the growth occurring as a skein of thread-like filaments and with colony formation. The threads present a beaded appearance by using Gram-Weigert's stain. In cultures portions of the filaments are acid-fast by the Ziehl-Neelsen Gabbett method, and they are also Gram positive. The entire mass from experimental lesions is often acid-fast.

Culturally the species is a facultative aërobe and grows on the majority of media. Growth becomes apparent on ordinary agar after two days, consisting of a smooth, adherent membrane which at first is porcelain-white, later developing a delicate, orange-pink color. The medium remains moist and is not colored in its depth.

Glycerine-agar, after about three days, shows a growth consisting of small, whitish colonies, which gradually develop a delicate pink color. Later, as the colonies progress, they become umbilicated and coalesce, forming a heaped-up growth and producing a bright, orange color. The medium becomes slightly darkened.

On *potato* the growth appears after about four days as a granular layer, at first white, later becoming yellowish and gradually assuming a brick-red color. As the colonies develop they become umbilicated, then coalesce and finally produce a moist, meal-like growth on the surface of the medium. The colonies can be lifted in heaps from the medium by the platinum loop, and when immersed in salt solution or distilled water readily disintegrate into fine, flat particles which float on the surface.

In *bouillon* growth appears after 48 hours in the form of small, flat particles which at first are white, but later assume an orange tint on the surface of the medium. As growth progresses, the colonies coalesce and produce a membrane on the surface of the liquid. Portions of this membrane fall to the bottom of the tube.

In *ascitic fluid* a very slight growth occurs after six days' incubation.

Litmus-milk shows growth on the surface of the medium in the form of fine, white particles which in time becomes pink in color. A film is gradually formed on the surface of the milk, which is neither coagulated nor changed in color.

Pathogenesis : The three cultures of this species, including the two strains from Foulerton as well as our own, are pathogenic for monkeys, producing on inoculation characteristic progressive lesions. (See animal experiments.) Typical Madura foot may be produced by inoculation into the feet of monkeys. Subcutaneous inoculation produces abscess-like pockets, containing a thick, viscid pus in which the colonies of the organism may be observed as small, white granules. Intra-abdominal inoculation results in tubercle-like formations with adhesions, breaking down of tissue with abscess and sinus formation. Granules made up of the colonies are present in the abscess contents.

No. 10. *Scapræ.* A study of this species from the culture sent us by Foulerton confirms in general the findings of Silberschmidt and of Foulerton. It shows characteristics which differentiate it specifically from any of the others with which we have worked.

Morphologically this organism more closely resembles the bacteria than the others and in its action on monkeys

it also resembles the tubercle bacillus quite closely. The filaments show true branching without club formation, and they are shorter than with most of the other species. Bacillus and coccus-like forms predominate in cultures and are also very prevalent in experimental lesions. It stains by the stronger aniline dyes in a somewhat irregular manner, is Gram positive and largely and strongly acid and alcohol fast.

Culturally it is a facultative aërobe and grows on most of the laboratory media. Growth first becomes apparent in from two to four days and progresses slowly. The cultural characteristics are shown in the accompanying table and need not be repeated here.

Pathogenesis : This organism is pathogenic for monkeys and guinea pigs and by intraperitoneal injection for rabbits. The lesions differ somewhat from some of the other members of the group in that there is much less tendency to suppuration or other form of tissue necrosis. The lesion is essentially a tubercle-like formation which spreads from the point of inoculation by the formation of other small granules. When studied miscroscopically these lesions resemble the tubercle quite closely, always contain the micro-organism and occasionally giant cells are encountered. The tubercle-like granules occasionally brake down and form small pockets of thick granular pus-like material, but this is the exception and granules made up of colonies of the parasite have not been encountered as in the other species.

No. 11. *S. canis.* This organism is probably identical with *S. capræ* of Silberschmidt. The only important points of difference in the cultures which we have are shown in the table, and consist principally in the difference in reaction in litmus milk. Morphologically and in its pathogenic action *S. canis* gives very similar results to *S. capræ.* The same tubercle-like lesions are formed in experimental animals and the close similarity in other respects has led to the conclusion that the two belong to a single species.

No. 12. *S. chalcea.* This is a non-pathogenic species reported by Foulerton and carried along in this work principally as a control. It is distinguished specifically from the other species by morphologic and cultural characteristics, and particularly by its being nonpathogenic for monkeys.

ANIMAL EXPERIMENTS.

The following are summaries of our animal experiments. The general results are placed under the discussion of the characteristics of the various species of the micro-organisms. A complete summary will be found in the chapter on general discussion and conclusions.

S. Nocard :

Monkey No. 3635, inoculated in the abdominal cavity with one loop of a two months' culture and the animal killed 12 days later. Autopsy shows numerous miliary tubercle-like granules extending over the entire surface of the omentum and mesentery with an occasional suppurative process. The pus when pressed out contains small yellowish-white granules made up almost entirely of the micro-organism.

Monkeys numbered 3722, 3726, 3714 were inoculated in a similar manner to the above. All showed similar lesions with the exception of monkey No. 3722 which gave a negative result.

Guinea pigs and rabbits inoculated in the abdominal cavity for the greater part developed similar lesions. Intravenous inoculation in rabbits gave negative results.

S. Eppingeri :

Monkey No. 3665 was inoculated in the abdominal cavity with one loop of a ten days' culture and the animal was killed thirteen days later. Autopsy shows numerous tubercle-like granules in the lower portion of the mesentery, with extensive adhesions of the mesentery to the abdominal wall. On separating the adhesions, or on section through them, numerous sinuses are exposed ; these hold a thick, viscid, pus-like substance containing numerous small grayish-white granules composed principally of *Streptothrix.*

Monkeys numbered 3664, 3633, 3622 were inoculated in a similar manner to monkey No. 3665 and the lesion produced were in all essentials similar to those found in that animal.

Foulerton's stram of S. Eppingeri.

Monkey No. 3725 was inoculated in the abdominal cavity with one loop of a ten days' culture and the lesions produced are similar to those found in animals inoculated with *S. Eppingeri* of the original strain.

S. maduræ.

Monkey No. 3854 was inoculated by opening the abdominal cavity and burying a loop of the material from a two weeks' culture of Strong's strain of the organism. Ten days later the animal presented a distended abdomen with a marked tympanites and was killed on this date. Autopsy shows numerous miliary tubercle-like processes in the omentum and mesentery and adhensions surrounding the inoculated material. The adhesions are easily separated and show small pinkish-white granules adhering to the mesentery.

Rabbits and guinea pigs inoculated subcutaneously, intravenously and intraperitoneally with this organism gave negative results.

Monkey No. 3856 was inoculated in the abdominal cavity with one loop of a two weeks' culture of Foulerton's strain of this organism and killed two weeks later. Autopsy shows a small, tumour-like mass made up largely of adhesions confined to the coils of the intestine, omentum, and abdominal wall. On section the tumour shows several small abscesses from which can be expressed a thick pus containing small, white granules composed almost entirely of the organisms. The latter are present in large numbers.

Monkey No. 3724 was inoculated in a manner similar to the above with negative results.

Guinea pig No. 3856 was inoculated into the abdominal cavity with one loop of a two weeks' culture and killed after 10 days. Autopsy shows slight adhesions of the omentum to the abdominal wall and intestine, but no other lesions are present.

Subcutaneous and intravenous inocluations of monkeys,

rabbits, and guinea pigs gave negative results in every case.

Monkeys numbered 3719, 3627, 3668 were inoculated with one loop of a two weeks' culture of Vincent's original strain of this organism. The inoculations were made subcutaneously and intraperitoneally and in no instance were progressive lesions produced.

Guinea pigs and rabbits inoculated subcutaneously, intravenously, and by intraperitoneal injections also gave negative results.

Actinomyces (from the Pasteur Institute):

Monkey No. 3864 was inoculated into the abdominal cavity with one loop of a two weeks' culture. The animal died three weeks later. Autopsy shows small abscesses in the abdominal wall at the site of inoculation and numerous miliary, tubercle-like granules in the omentum and mesentery. The pus from the abscesses contains many minute, hard, black granules which by microscopic examination are seen to be made up of a net-work of mycelia and transformation products of the micro-organism.

Monkeys numbered 3622 and 3623 were inoculated in a similar manner and presented similar lesions to the above. Intravenous, subcutaneous, and intraperitoneal inoculation of rabbits and guinea pigs gave negative results in each case.

S. capræ:

Monkey No. 3858 was inoculated into the abdominal cavity with one loop of a two weeks' culture and ten days later the animal was killed. Autopsy shows numerous miliary, tubercle-like bodies on the mesentery, diaphragm, and on the surface of the liver. There is slight adhesion of the omentum to the abdominal wall at the site of the inoculation.

Monkey No. 3625 was inoculated into the subcutaneous tissue and into the peritoneal cavity with a suspension of this organism. The animal died three weeks later. Autopsy shows extensive adhesions around the site of inoculation and there is a large abscess in the abdominal wall. On section the abscess contains a heavy, creamy, pus-like material in which are numerous, minute, grayish-white granules. These granules are composed of micro-organisms and a pure culture is easily obtained by transplanting the granules to artificial media.

Guinea pig No. 3859 was inoculated in a similar manner as were monkeys numbered 3858 and 3625 and the lesions produced were similar to those described for the monkeys. Intravenous inoculations of rabbits gave negative results in the animals used.

S. canis:

Monkeys numbered 3633 and 3626 were inoculated in the abdominal cavity with one loop of a two weeks' culture and a two months' culture of this organism, respectively, and both animals were killed two weeks later. Autopsy shows slight adhesions near the site of inoculation. The omentum and mesentery are intensely congested and contain numerous miliary, tubercle-like granules.

Monkeys, guinea pigs, and rabbits inoculated subcutaneously showed no progressive lesions at autopsy. Intravenous inoculation of rabbits gave negative results. Intraperitoneal inoculation of guinea pigs in two instances produced lesions similar to those described for intra-abdominal inoculations in monkeys.

S. chalcea:

Monkeys, guinea pigs, and rabbits when inoculated subcutaneously and intraperitoneally gave negative results.

LITERATURE.

If we carefully study the literature of species determination, it will be found in greater part to be only of historic interest and value. The work is generally too incomplete to be final for species determinations, and in cases even the generic position of the described parasites is doubtful.

It is certain that they do not all represent different species and it is probable that some of the other organisms not included do belong to new species. Many of the articles in the literature are incomplete, and a careful study of such descriptions as are given convinces us that not more than ten different species are represented in the group. Several of the varieties may show slight morphologic and biologic differences, but these are not sufficient to warrant their being classed as separate species.

GENERAL DISCUSSION AND CONCLUSIONS.

The subject of streptothricosis or nocardiosis becomes somewhat simplified if the results of our own work are combined with those taken from the literature, but we realize fully that after considering all possible evidence, points must still remain open for discussion, and complete harmony regarding this subject can only be obtained by common adoption of a somewhat arbitrary classification.

DETERMINATION OF GENUS.

It is difficult to determine upon the correct name of the diseases, because of the botanical confusion regarding the position and designation of the group of organisms concerned, and of the lack of clearness of definition specifying definite limitations for the organisms to be included as the etiologic factor.

Both *Streptothrix* and *Actinomyces* are untenable as generic names if we strictly follow the rules of nomenclature, because they are not entitled to priority in the literature which belongs to *Nocardia*, besides both *Streptothrix* and *Actinomyces* are open to the objection that they have not received a sufficiently clear botanical definition and both names have been used in too uncertain a sense in the past. *Actinomyces* has also, unfortunately, been taken into recent literature with practically two definitions. The objections to *Nocardia* are as follows: (1) The published definition erroneously states that the branching is "false branching," (2) the name has not been sufficiently accepted by botanists to insure permanency, and (3) usage is very much against it, particularly as in some of the recent writings its meaning has been limited to include only a portion of the organisms which surely belong in the genus. Considering the confusion in botanical literature and the uncertainty, and therefore the liability to change which pertains to this nomenclature, we have, as stated in the introduction,

chiefly because of usage, and therefore somewhat arbitrarily, tentatively accepted *Streptothrix* as the generic name of the organisms concerned, and streptothricosis as the designation of the disease caused by this group of branching, filamentous organisms. In making this decision we are fully aware of the rights of those who favor *Actinomyces* or *Nocardia*, and under the circumstances are tempted to introduce a new name (*Carterii*) for the genus, together with a full and complete definition.

Whatever the nomenclature, it is a fact that we have here a group of closely allied vegetable parasites of man and animals, which have the following principal characteristics:

Branching, filamentous organisms which develop into colonies made up of the organisms and "transformation products." The terminal hyphæ may or may not be radially placed on the surface of the colony and they may or may not develop "clubs." The group in general take Gram's stain and several members show acid-fast properties in a varying degree.

The organisms grow on artificial media, differing in their requirements for oxygen and in pigment production. To a less degree they show other variations in appearance on artificial media.

The majority of the organisms produce lesions in monkeys, which histologically resemble those found in the human infections and in those of other animal diseases caused by members of this genus.

This group or genus is closely allied to other genera of somewhat similar characters, the latter ranging from the branching bacteria through the non-branching filamentous *Leptothrix* and the pseudo-branching *Cladothrix*, to the budding *Oidia* or *Blastomyces.*

The only question of doubt regarding the expediency of our generic classification is raised by the very thorough and exhaustive work of James Homer Wright, who has brought forward some strong arguments in favor of making two genera out of the group of organisms under discussion.

As may be remembered, Wright separates this group into two genera: *Actinomyces* and *Nocardia.* He defines *Actinomyces* accurately and places all the organisms which he thinks do not come within this definition into the genus *Nocardia.*

Actinomycosis is defined as:

"A suppurative process combined with granulation tissue formation, the pus of which contains characteristic granules of 'drusen' composed of dense aggregates of branched filamentous micro-organisms and their transformation of degeneration products. In the term transformation products are included the characteristic, refrangent, club-shaped bodies radially disposed at the periphery of the granule, for these bodies have long since been clearly shown to arise by a transformation of the peripheral filaments. They may or may not be present at the periphery of the granule."

Wright, in his further discussion of the organisms, emphasizes the following points as being characteristic of *Actinomyces.*

Club formation in tissues, anaërobism, granule formation, peculiarities in culture media, morphology and action when injected into laboratory animals. However, some of these distinctions were not constant even in the author's series of cases.

If we accept Wright's definition of actinomycosis, some of the organisms termed *Nocardia* by the author must be included as etiologic factors in actinomycosis, because the requirements are fulfilled bymicro-organisms not included in his description of the organism which he considers the specific cause of the disease; and furthermore, if his definition and description of *Actinomyces* be accepted as sufficient for genus determination, other genera could be removed from the group with almost, if not with equally good cause. However, some of the principal characteristics given for *Actinomyces* are not peculiar to his organisms. Most of these are differences in *degree only* from other members of the group, and are not specific, and in some instances, as we have demonstrated by work with original cultures, Wright's conclusions, based upon a study of the literature, are wrong. His observations regarding *S. capræ* Silberschmidt, and *S. maduræ* Vincent are examples of this. Wright states that Vincent's case was probably one of actinomycosis, and that Silberschmidt worked with mixed cultures. We have had cultures from the original strains of both these organisms in our hands and are able to state positively that the bacillus and coccus-like forms of *S. capræ* described by Silberschmidt are forms of the pure culture and not bacterial contamination. As to Vincent's case, the organism is distinctive and cannot possibly be included in Wright's definition of *Actinomyces;* indeed, it forms one end of the *Streptothrix* group, while the *Actinomyces* of Wright forms the other.

SPECIES DETERMINATION.

Species determination in this genus is made extremely difficult, and classification of all the forms which have been given in the literature is impossible, because of the incomplete and imperfect descriptions which are given. Several of these descriptions are old, have not been repeated or confirmed, and are lacking in the elucidation of important points which are now recognized as essential for diagnosis. Our correspondence has elicited the fact that cultures of several of these species are no longer obtainable, and, therefore, no further study of them can be made. Fortunately, we have been able to secure cultures of the most important members of the group and by comparative morphologic and biologic studies, particularly with reference to their pathogenic character, we have been able somewhat to simplify the classification by showing that some of the described species are identical. This includes *S. Freeri*, which from a study of the literature we thought to be a new species, but after comparative study found to be identical with *S. Eppingeri* in all essential particulars.

Another difficulty in establishing species or varieties is encountered in attempting to fix the amount of variation necessary to constitute a new species. The differences between various members of the group are practically in every instance those of degree only. For example: in the requirements for oxygen we have variations from facultative anaërobism with strong tendencies toward

being negative to oxygen, as exemplified by the Wolf, Israel and Wright type of *Actinomyces*, to facultative aërobism with strong oxygen requirements, as exemplified in *S. Eppingeri;* while other strains show intermediate stages of aërobiosis. Although strict anaërobes and equally strict aërobes have been mentioned, the conclusions probably are based upon errors in technique. Certainly this is true with the organisms with which we have worked, for in no instance have we encountered either a strict anaërobic, or an equally strict aërobic *Streptothrix*, although some of the cultures under our hands have had such properties ascribed to them by others.

Staining reactions.—The terminal filaments in lesions and young cultures usually stain very well by the usual aniline dyes, but in older colonies the central detritus does not stain and the filaments give irregular staining reactions often showing irregular, including coccus and bacillus-like, forms. The reaction to Gram's solution is somewhat variable, depending upon the age of the colonies, and there is some variation between the different species or varieties. However, in general, all strains are Gram positive to a greater or less degree.

Differences in *acid fast* properties have been used as being diagnostic in a number of described species, while unfortunately in others they have not been mentioned. These are important points in differentiation, but unfortunately such properties are a somewhat variable manifestation, depending in part upon the age and environment of the parasite and perhaps also upon other conditions, the nature of which is not clear. As with the oxygen requirements, degrees from the marked acid fast properties of *S. Eppingeri* through those organisms showing the tendency only in certain portions to *S. maduræ* which has no such properties are noted. *S. Eppingeri*, often when taken from animal lesions and sometimes for example in cultures, will show acid fast properties which involve the entire organism, while in other cultures only portions of the organism will retain the fuchsin when decolorized and counter stained with Gabbet's stain.

Pigment production under certain circumstances is a property of most of the organisms of this group, as the cause of this is unknown and the result is variable, its diagnostic importance is lessened. Under like conditions, the color and general appearance of the pigment in any of these strains is usually fairly constant, but sometimes, particularly in animal tissues, it may show a more intense color. For example, *S. maduræ*, which usually produces a reddish-pink pigment in cultures may, when inoculated into monkeys, at one time give a similarly colored pigment or again one considerable darker; so dark in fact as to appear almost black to the naked eye. The pigment of *Actinomyces* in our culture shows but little color other than black. On media the color develops slowly and gradually to a dark grey, almost black. Some of the phenomena of pigment production and color may be explained, but in general the process is still obscure. For example, a darker pigment usually results in animals from the inoculation of fresh material from another animal than is the case if cultures are used. The next lighter shade is produced by inoculation with old, pigmented cultures, but color production is slower when young, unpigmented cultures are used for inoculation. Early pathologic lesions due to these parasites, like young cultures, rarely show pigment. The latter in both instances is produced and grows more marked with age. Concentration undoubtedly has something to do with the apparent color of the pigment, for the harder the granule the darker the pigment appears to be.

Granule formation both in tissues and, to a less extent, in cultures, is a property of all the pathogenic *Streptothricæ* with which we have worked. These granules vary considerably in consistency and color in the several species, but in the majority of instances they are made up of branching filaments with transformation products, which consist in irregular forms, crystals and unstainable detritus. The arrangement of the peripheral filaments may or may not be radial and there are various degrees of density of the mass. In two of our cultures (*S. canis* and *S capræ*) there is less tendency to suppuration after inoculation in animals, and the individual colonies have more the appearance of tubercles than in our other cultures. This difference has been pointed out by other observers. However, the lesions in our experimental animals were small; in the older lesions the type of the granule is not known, if we except the knowledge gained from the statements of the authors who described the parasites, the description being taken from the original lesions. The granules or colonies produced by the other cultures were in the majority of cases free in the necrosed, liquefied substance found in the various channels produced by these infections.

Club formation, in the lesions, in tissues and less frequently in cultures, is used as one of the points of differentiation between species of the organisms of this group. No doubt there is considerable variation in this respect under certain conditions, but the circumstances reported as surrounding club development are sufficiently varied and confusing to detract somewhat from what would otherwise be valuable for purposes of distinction.

Wright found club formation to be rather constant in original lesions, and observed it occasionally in certain cultures. In experimental lesions, it was also fairly constant, except in early lesions where clubs were sometimes absent.

Bostroem and others, working with species differing somewhat from Wright's organisms in other particulars, also observed clubs both in lesions in animals and occasionally in cultures.

None of our cultures show definite clubs in culture or in experimental lesions in animals, although in several the terminal branches show some enlargement suggesting club formation (see illustrations). Our experimental animals were all killed within a shorter time after inoculation than were those of Wright, in which clubs were found.

Branching is similar in all of our cultures and is also similar to that recorded by most observers who have worked with this group of micro-organisms.

The cultural characteristics of all of our strains have already been described. While there are variations in the reactions between some of these strains, they all

appear to belong to one group of organisms, and, if we analyze the literature carefully, others, including the organisms of Wright and of Bostroem, may also be included in the group.

The following may be noticed if we take up the principal cultural characteristics comparatively as well as somewhat more in detail.

Surface growth is considered to be poor in Wright's organism and is not very profuse in some of our strains, but in Bostroem's organism, and in most of ours, while it may be slow, it does occur in a satisfactory manner and in some strains it may be luxuriant. There is but little tendency for surface growth to spread in any of the cultures, but, on the other hand, it heaps up, as it were, giving raised colonies sometimes 1 centimeter above the surface of the media. (See plates.) This is also true with Wright's organism, where surface growth appears.

Wright first called particular attention to the character of growth in glucose-agar suspension cultures. In this medium, with his organism, there is a narrow zone 5 to 10 millimeters below the surface where the colonies are very numerous but small, while lower down they are less numerous, but of larger growth. Surface growth is the rule in our cultures in this medium, and only occasionally a colony may develop in its depth.

Stab cultures in sugar-agar.—Growth with Wright's organism occurred in small nodules along the course of the needle, it did not penetrate the medium to any extent and did not grow on or near its surface.

The growth in our cultures occurs mainly upon the surface and upper portion of the track of the needle.

Anaerobiosis.—Wright considers his organism as an obligate anaërobe, a statement which is somewhat qualified in the details of his work. For example, in discussing the growth upon glucose-agar suspension media, he states that the most profuse growth of the organism is in a narrow zone 5 to 10 millimeters below the surface of the medium and that this way may be "explained as the result of a stimulating action exerted upon the growth of the micro-organisms by the presence of a small amount of oxygen which has penetrated into the medium from the surface." This oxygen requirement is further illustrated by the author when he states that "in sugar-agar suspension cultures, placed under anaërobic conditions, there is little or no tendency to form colonies on the surface."

Growth occurred along the course of the needle only in stab cultures on glucose-agar. It did not penetrate the medium and, on the other hand, did not grow on the surface. However, when discussing growth upon surface inoculations in slanted solid media, Wright found that surface growth was not luxuriant and in some of his strains no growth occurred even under anaërobic conditions. Again, Wright observed that "in general, growth appears to be as luxuriant in bouillon either under aërobic or anaërobic conditions." To judge from the above and other statements which might be taken from Wright's excellent monograph and *according to the standards used in this report* for the other members of the group, Wright's organism must be considered to be a facultative anaërobe.

In *bouillon* media there is some variation between the manner of growth of our cultures, but little which may be considered of value in the differentiation of species. The tendency in some of our cultures is toward a surface growth which may gradually separate and fall to the bottom, or settle on the sides of the tube. In other instances, the majority or all of the growth may occur at the bottom of the tube. The medium is not clouded, but in some cases it becomes darker, apparently because of the absorption of pigment from the organisms. There are no essential differences between our cultures in bouillon and those reported by Wright.

Potato, as is well recognized, is not a very satisfactory medium for comparative studies, excepting where the same set of media is used. Fairly luxuriant growth was obtained in every instance with our cultures on potato slants.*

There was not much variation between the different cultures except in the color of the pigment and the appearances which have already been described. Potato proved itself to be a very unsatisfactory medium for Wright's organism. Most of his strains grow on it very poorly, and some of them not all.

Litmus-milk is not a favorable medium for the differentiation of species. Growth takes place slowly, and with two strains the color is slowly discharged. No other appreciable changes occur in the medium excepting with cultures of "chalcea," in which a slightly acid reaction is produced.

The favorable influence of *sugar* and *glycerine* upon cultures of all strains of the group of organisms has been noted repeatedly. Sugar or glycerine containing media are not only the best in securing growth, but with all our species pigment production is more active in these media.

Pathogenic characters.—The pathogenic character of many varieties of this group of organisms in the human and animal economy is well established. However, experimental inoculations in animals have not given constant results in the hands of other investigators, and our experiments have been uncertain with all animals except monkeys. The details have already been described and it only remains to state here that lesions similar in their gross and histologic appearances to the original ones produced by these organisms, have resulted with each of the strains which we have studied, except with one of the strains of *S. maduræ* which has already been mentioned in this discussion.

CONCLUSIONS.

There is, in human pathology, a very important group of branching, filamentous micro-oganisms which logically belong to a single genus. The generic name is variously given as *Streptothrix Actinomyces* or *Nocardia* ; the last of these names is probably scientifically the most correct, but, because of the present botanical confusion and uncertainty, the first is here employed because of its more general acceptance.

* The potato slants employed in this laboratory are made from selected potatoes treated and prepared according to the rules laid down by the committee of the American Public Health Association.

The following species to judge from our work and from a study of the literature are the most important and may be recognized as established. There are probably a number of others, but the description of many of them are too imperfect to allow of their recognition.

S. actinomyces Bostroem, 1890.

S. Actinomyces Wolff & Israel, 1891 and Wright, 1905.

S. Nocardii.

S. Eppingeri.

S. maduræ Vicent.

S. capræ Silberschmidt.

The disease caused by infection with these parasites is properly named streptothricosis, with actinomycosis and nocardiosis as synonyms. Other names, such as lumpy-jaw, madura foot, mycetoma etc., should be considered more as describing anatomic location rather than as designations relating to any special or specific cause of infection. Mycetoma might well be taken as the correct name for the group of infections if a strict interpretation of rules of nomenclature is followed, but usage renders it perhaps more desirable to retain the name as representing *Streptothricosis pedis.* If mycetoma is to be considered in any more comprehensive light than this, it should become another synonym for streptothricosis. It should not be considered a disease caused by organisms other than *Streptothricae.*

Part II.

STREPTOTHRICOSIS.

Synonyms.—Actinomycosis, Nocardiosis.

Definition.—An infectious disease of man and animals caused by one or more species of *Streptothrix.* It is characterized anatomically by a peculiar, low grade of inflammation, usually confined to one part of the body, but in rare instances assuming the proportions of a general infection. The inflammatory process usually is accompanied by suppuration of a certain kind; the discharges contain granules made up principally of colonies of *Streptothrix.* The general picture of chronic inflammatory disturbance is seen clinically, and enlargement, suppuration and the presence of the causative organism in the lesions is observed locally.

History.—The history of *Streptothrix* infection is shown in the review of the literature given in Part I. In general it may be stated that the disease has probably long been recognized and frequent references are made in older medical literature to conditions which presumably were due to infection with these micro-organisms. According to Rivolta, Trutto discussed the condition among cattle in Italy in 1785 under the name of "Krotenkrankheit." The colonies of the organisms were more or less accurately described by Langenbeck (1845), Sir T. Smith (1855), Lebert (1848), Rivolta (1868), Robin (1871), Heller (1872), Perroncito (1875), and others (see Ackland). Mention of the anatomical form of the disease generally described as mycetoma or Madura foot are also quite old, the principal authors being Kämpfer (1712), Heynes (1806), Brett (1840), Gill (1842), Godfrey (1844), Colebrook (1844), Gunther (1844), Eyre (1848), Bollingol (1855), Eyre (1860), Collos (1861), Bidie (1862), Hirsch (1868 and 1886), Coquerel (1866) and many others (see *Phil. Jour. of Science, Sec. B.* (1907), 2, 487). Of these observers Colebrook (1850), Bollingol (1855), Coquerel (1866), Maxon and Hogg (1870), Bristowe (1871), Berkeley (1876), and others probably saw and in a few instances partially described the organisms present in the lesions. However, the really important history of *Streptothrix* infections dates from Vandyke Carter's work (1859-1874). This author described and illustrated the parasites in many cases of the foot (Madura foot) type of the infection. Bollinger and Marz (1876), first accurately described and named one of the parasites causing the disease known as lumpy-jaw in cattle. The next epoch in the history was due to an article by J. Israel (1878) who was the first to describe the disease and parasite in man in locations other than the foot (Madura foot) and hand, the infection in these places already having been described by Carter and others. Israel's work was followed by that of Ponfick (1879) with strong evidence as to the identity of the disease in man and animals. From the year 1876 the literature accumulated rapidly and the infection was reported for man and animals from widely varying locations and countries.

Bostroem (1890) contributed the first thorough and exhaustive laboratory study of the micro-organisms and this work was followed a year later by an equally exhaustive treatise on the same subject by Wolf and Israel. The organisms described by Bostroem on the one hand and by Wolf and Israel on the other, although isolated from apparently similar diseases, showed certain morphologic and biologic differences which led to much discussion during the next few years. Organisms corresponding to the descriptions of both these pioneer observers continued to be mentioned in the literature, each investigator maintaining his organism to be the true cause of the disease.

In 1888 Nocard cultivated and quite accurately described a *Streptothrix* as the cause of a disease locally termed *farcin de boeuf* of cattle in Guadalupe; Nocard's organism seemed to be of a different species from either Bostroem's or Wolf and Israel's. Eppinger (1890) cultivated and accurately described another species of *Streptothrix* as the cause of a brain abscess and "pseudo-tuberculosis" in a man. Vincent (1894) first satisfactorily cultivated and described a *Streptothrix* as the cause of mycetoma or Madura foot and his organism seemed to have certain characteristics showing it to be specifically different from any of those previously described.

Foulerton (1899-1907) gave descriptions of several new species of the parasites and has brought out the most thorough and exhaustive consideration of the whole subject with which we are familiar. Wright (1905) contributed a most complete and exhaustive study of the biology of the Wolf and Israel variety of this organism. The work of bringing all this group of similar organisms together in a single genus is largely due to the researches of Rossi Doria, Petruschky, Foulerton and several other recent writers, particularly of the German and French observers.

In this article we have shown conclusively that Eppinger's organism isolated from clinical actinomyces on several occasions is identical with *S. Freeri*, which is one cause of Madura foot in the Phillipine Islands Very little is known regarding *Streptothrix* infections in this Archipelago. Our records show two cases in which *Actinomyces* was the etiologic factor in human disease, and several infections of cattle have been observed in the islands. One case of the Madura foot type of the disease has been seen.

ETIOLOGY.—*Predisposing causes*, for this disease, except in a few instances, have not been sufficiently studied to make a satisfactory estimate of their influence.

The *geographic distribution* is very wide, but no very large series of cases have been studied by any one observer. Collections of such series have been made in America, Germany, France, England, Russia, Switzerland, and in the British colonial possessions. The most frequent incidence is found in certain parts of the Tropics, particularly in India, but, as has been pointed out by Ackland, the disease may be overlooked in a community for a long time until special attention is called to its prevalence.

According to available statistics the infection is more frequent during young, adult life, but cases have been reported in children and in old people. Males are much more frequently affected than females—295 males to 110 females being given in Leith's statistics, and 65 males to 36 females in Ackland's.

Race, nationality, residence, overcrowding, climate, occupation, and physical condition, to judge from available statistics, seem to exert but a minor influence on the spread of the disease, although a more careful study of a large material may show some of these to have greater significance.

General environment and *mode of living* would naturally be expected to have considerable influence as predisposing factors, particularly in determining the part of the body involved. For example, the Madura foot type of infection is most common among people who go barefoot, it being largely a wound infection.

Streptothriceæ are the specific, causative agents of the infection. They have already been considered in Part I of this report, and only a brief summary will here be given.

SYNONYMS.—*Actinomyces, Nocardia, Oöspora, Cladonyphe Carteri.*

DIAGNOSIS of these organisms is made from morphologic and biologic considerations. They are branching, filamentous organisms, which develop slowly into colonies made up of the branches and their "transformation products." These colonies vary in color, size and consistency, and when stained show various changes in different portions. The filaments at the periphery are usually intact, with or without club formation, and the terminals may or may not be radially placed. Toward the center of the colony, or granule, irregular forms, such as coccus- and bacillus-like ones, are found, together with crystals and non-staining detritus.

The majority of these organisms may be cultivated on artificial media, where they show various but characteristic biologic properties. That some of them are pathogenic tissue parasites is shown by their action on laboratory animals.

Morphologically these parasites are rather closely related to some of the branching bacteria. The young filaments vary in width from 0·5 to 1 μ and in length from 5 to 20 μ or more. They usually stain homogeneously, and in some strains taken from lesions they are acid-fast to the Ziehl-Neelsen-Gabbett method. In older forms the segments are often broken, the sheath-like substance not showing either in fresh or stained specimens. The breaking up of the filaments produces great variety and size of irregular forms; some of these may appear to be very much like bacteria, but their true nature is easily established by laboratory methods. The majority of these organisms may be stained by the aniline dyes, all show Gram positive characteristics to a greater or less degree, and several are as acid-fast as is the tubercle bacillus.

Biologically certain species—both saprophytic and pathogenic—are widely distributed in nature. They have been found on food stuffs—particularly cereals—in water, air, soil, etc. Zoölogically they are found in some insects and several animals, and in man. Cattle are the most frequently infected of the animals, but rarer instances of the disease have been reported for other species.

Cultivation of these organisms is probably possible with all species, although several authors have reported failures, and all observers have noted the difficulty of obtaining a culture from the lesions in animals. However, when adaptability to artificial media has once been secured, no very great difficulty is found in keeping the culture. In general, it may be stated that these organisms grow slowly on artificial media, but that the cultures show most positive characteristics in the majority of instances. In all there is a tendency to "pile up" on the medium rather than spread over the surface. Pigment production of various shades is a very common property, and this is more marked as a rule in glycerine or glucose containing media.

Resistance to physical, chemical, and other agents by these organisms is rather great if we consider them to be non-spore bearing parasites, but this resistance is not sufficient to permit us to consider that true spore formation is present as it is understood for bacteria.

PATHOGENIC CHARACTER.—The pathogenicity of several species of *Streptothrix* has recently been demonstrated by different workers, according to the accepted bacteriologic rules governing such decisions. Other members of the group appear to be saprophytes in that they do not produce lesions in animals by the usual methods of procedure. There is also considerable lack of uniformity in the results of animal experiments with nearly all the pathogenic strains. However, working with monkeys, our results have been more uniformly successful than those reported by other observers, or than our own results with other laboratory animals. The pathogenicity of this group of organisms seems to be influenced to a certain extent by the same conditions which produce changes in the virulence of bacteria. Not only may the virulence of some of these species be increased by passage through

susceptible animals, but with the increased virulence differences in cultural results may be noticed. These are shown principally in greater difficulty in securing growth, in a slower growth on artificial media and sometimes in slight changes in the color and quantity of pigment productions.

Some of the so-called saprophytic species may in reality be found to be pathogenic when improved technique is used.

Modes of transmission.—Although experimental evidence is still far from satisfactory regarding modes of transmission, it seems to be entirely reasonable to assume, from the known biology and the available evidence, that transmission may take place both directly and indirectly. So far as we are aware no positive examples of direct transmission from person to person have been reported, but that such infection does not take place, in localities with high incidence of the disease, seems probable. Rather convincing evidence of indirect transmission through the agency of food-stuffs, water, etc., has been furnished by several observers. Several authors, whose work has already been reviewed, have shown that pathogenic species may be isolated from water, air, soil, and food stuffs and the history of many of the reported cases indicates infection from some such source. The frequent presence of the infection in the lower animals must not be forgotten in considering the manner of transmission of the parasites.

Infection probably takes place in two general ways, first by direct or wound infection, as is shown in many cases by the history of injury before the development of the symptoms of the *external* forms; and secondly, infection by way of the respiratory or gastro-intestinal tracts, which is shown in many of the *internal* forms of the disease.

Species.—The number of species important in this disease is probably a considerable one. Those which we have been able to recognize from the literature and our own work are given in Part I.

It seems probable that all the species have not, as yet been discovered and that some, which have been described are specifically different from the ones mentioned here.

PATHOLOGY.—In general the morbid changes found in this disease are those of a peculiar, low-grade, chronic infective process. Anæmia, atrophy of tissues, and mild, chronic degenerations of parenchymatous organs are present. The special pathology depends somewhat on the part of the body involved and on the extent of this involvement. The streptothritic unit, as it were, is a granule which is usually surrounded by a zone of peculiarly appearing suppuration, and this in turn by an area of inflammation characterized by connective tissue proliferation and cell infiltration. Cells of the usual character are found, with a relative increase of fixed tissue cells and occasionally a giant cell. In other instances the suppurative zone is absent and the streptothritic unit takes on more the general and histologic appearance of a tubercle. In fact, the whole morbid process of a *Streptothrix* infection resembles more or less closely that produced by *Bacillus tuberculosis*. Tissue destruction often spreads by means of continuity, but more usually by intercommunicating channels running in various directions. These channels contain the broken down tissue and granules made up of colonies of the infecting organism. Few tissues escape the destructiveness of the *Streptothrix*, but it appears to be more active in the connective tissues, bones, and mucous membranes. However, practically every organ and tissue of the body has been involved. The disease spreads through the body in at least two ways, by directly continuing along the tissues, in which case the area involved is rarely great, and by metastases through the blood vessels, when the infection may be so great as fairly to be considered a general infection.

The character of the morbid process suggests that the minute action is toxic in character, although, if such is the case, the toxin must act very slowly. The lymphatics near a diseased process may be enlarged, but are rarely found to be broken down or to contain the micro-organism.

SYMPTOMS.—The clinical manifestations of *Streptothrix* infections are essentially those of a slowly developing, chronic inflammatory process. They vary much with the location of the lesions and further complications are secured by the presence of mixed infections which are frequent when the disease attacks regions of the body exposed to bacterial invasion. In many instances, where the lesions are located in the internal organs such as the liver, definite clinical manifestations do not occur, and, unless the infection spreads, its nature in all likelihood is not recognized during life.

When the lesions are located externally, or in places where the discharges reach the surface of the body, the nature of the infection should be suspected from the appearance of the wound and the character of the discharges; on the other hand, it may be generalized, manifest itself in an acute course and be difficult to distinguish from a pyæmia of other etiology.

The *incubation* period varies between wide limits, and as given by authors may be from a few days to more than two years. The onset is usually gradual, by the slow development of the lesions.

The following clinical varieties may be recognized:

Generalized streptothricosis.—This form of infection has been noted by several observers. It occurred 9 times in Ackland's 109 cases. This type usually begins in a local lesion and is transmitted through the blood vessels. In the majority of instances, it occurs in mixed infections with bacteria, but cases in which no bacteria were present have also been reported. Several species of the organisms causing these general infections have been found. This type is generally acute or subacute clinically and the symptoms, as given by various authors, are similar to septicæmia or pyæmia from other causes. Extensive lesions may occur in practically every organ and tissue of the body. The diagnosis is only made by laboratory methods, the prognosis is bad and treatment unsatisfactory.

Thoracic streptothricosis.—The organs of the chest, particularly the lungs and pleuræ are most frequently involved in this disease. It occurred 65 times in 257 cases reported by Duvan and 29 times in Ackland's 109 cases. The clinical symptoms in the lungs and the physical signs may resemble a chronic tuberculosis or severe bronchitis and the pleural involvement may consist of

chronic, adhesive pleuritis or more often of empyæma. Unless there is perforation of the chest wall or metastases, the clinical manifestations in these types show nothing characteristic of the disease and the true nature of the infection can only be determined by laboratory methods. Streptothricosis of the heart and mediastinum have been reported, and Ackland notes nine cases involving the æsophagus.

Abdominal streptothricosis, including all the organs of the abdominal and pelvic cavities, have been reported by various observers. The liver and gall bladder suffer most often. Involvement of these viscera occurred forty times in Duvan's series and thirty-three in Ackland's. The appendix is quite frequently involved and in some instances is the primary seat of the lesions.

Other lesions are found in the mesentery, intestine, rectum, spleen, bladder, prostate, testicle, kidneys, and abdominal wall. In none of these types are there any characteristic clinical manifestations which differentiate this infection from other chronic inflammatory conditions of tuberculous or other etiology in the same locations.

Cerebral streptothricosis includes involvement of the brain, cord, meninges and nerves, as well as the other tissues in these organs. The central nervous system was involved 19 times in Duvan's 257 and 5 in Ackland's 109 cases. Several different species of the organisms have been found in these lesions, that of Eppinger being the principal one. This species, as has been shown in Part I of this report, is identical with *S. Freeri* which caused the mycetoma in our case. The reported cases show no characteristic symptoms in these types of infection.

External streptothricosis may involve any of the external or contiguous tissues, including the mouth and jaw, neck, skin, and subcutaneous tissues, conjunctiva, nose and extremities. "Lumpy-jaw" or "big-jaw" is one of the most frequent of these various types; mycetoma, Madura foot or *streptothricosis pedis* is a very common tropical type and others involving many anatomical locations are frequently encountered. Practically all described species of the genus of the organism have been found at one time or another in external streptothricosis, and there does not appear to be much variation in the clinical picture because of any special species or variety. The clinical manifestations of external streptothricosis are rather characteristic. The peculiar, crater-like skin lesions of a chronic character leading through ramifying channels—through which is discharged the peculiar, oily, pus-like substance containing granules—makes a rather constant and characteristic picture. As we have already stated, mycetoma or Madura foot is best classified here as the clinical type of *Streptothricosis pedis*, because it may be caused by several if not any of the species of this genus and the clinical manifestations are practically the same in all cases. The special symptoms of this type are well known and have already been discussed in this report.

Miscellaneous types of streptothricosis may be mentioned, such as involvement of the conjunctiva, bones, ear, nose, intercostal spaces, etc. Their only peculiarities are in the anatomical locations of the lesions.

Diagnosis.—The diagnosis of *Streptothrix* infections is made clinically by the character of the exposed lesions and discharges and by laboratory methods. Obviously, the common and frequent involvement of internal organs is rarely recognized except by microscopic examinations at operations or at autopsy. The thoracic types may be determined by microscopic and bacteriologic studies of the sputum or aspirated fluid from the pleural cavities. It is generally stated by competent observers that these types are frequently overlooked, even in sputum examinations, and it is not improbable, because of the acid-fast properties of some of the organisms, that they may occasionally be mistaken for the tubercle bacilli. The resemblance may, at times, be quite close. In some of our experimental lesions the similarity has been striking. The microscopic examination of material from exposed lesions often requires some patience and care to enable the observer to find the organisms unless a granule is encountered, when, of course, the determination is easy. Inasmuch as some other closely related organisms such as *Oidia*, *Leptothrix* and *Cladothrix* may cause somewhat similar lesions, *Streptothrical* should not be diagnosed positively without careful microscopic study of the organisms present in the lesions.

Prophylaxis.—From what we know of the distribution of the organisms of this disease, and the mode of transmission, and the prevalence of certain anatomical types, prophylaxis should consist in guarding against wound infection and generally by care in food and drink. In the Tropics most of the types consist in local foot or other skin wound infections, which should be guarded against by wearing shoes and by promptly treating skin wounds and abrasions according to antiseptic methods.

Prognosis.—The prognosis depends to a considerable extent upon the location and extent of the lesions. The general infections and those of the internal organs almost always end fatally. The external types are much more amenable to treatment and the mortality is small.

According to the statistics of Duvan and Poncet and Berard who analyzed 257 cases, the mortality was as follows: Skin, 2·3 per cent; face and neck, 10; jaw and temporal region, 30; abdominal cavity and intestine, 65; thoracic, 85; liver, 100; and brain and spinal cord, 100 per cent. The mortality in mycetoma, under proper treatment, is very small. The course of the disease is usually chronic, but it may be general and acute and general infection may take place during the course of a chronic localized type of the infection.

Complications.—While streptothricosis may be found together with a number of other diseases, or may develop its symptoms as sequelæ of other diseases, the principal direct complications are those due to mixed infections of bacteria. Several of the pathogenic bacteria have been found associated with *Streptothricæ* in lesions and the course and outcome of the disease is influenced accordingly.

Tuberculosis, because of its close clinical relations to streptothricosis and the frequent lung involvement of both organisms, has led to confusion in some of the reported cases.

TREATMENT.—The varieties of treatment most useful in this disease are general as well as local surgical intervention if eause is indicated, and a combination of all of these methods may be necessary. Potassium iodide administered in large doses over a long period of time is generally admitted to have a favorable influence on the course of the disease, and complete cures have been reported from this method of treatment. Local measures eonsist in antiseptic dressings and the use of the Roentgen rays. Surgical measures consist in drainage, removal, or amputation according to the location and extent of the lesions. A combination of all three forms of treatment would suggest itself as offering the most favourable opportunity for recovery.

MYCETOMA OR FUNGUS FOOT-DISEASE.

By N. F. SURVEYOR, M.A., M.D. (BOMBAY), M.R.C.P. (LONDON),

Professor of Bacteriology, Grant Medical College.

Mycetoma or Fungus Foot-Disease, I won't say of India because this disease has been found in Europe (Bassini), Africa (Vincent), and America (Wright)[1], has like, most diseases of the Tropics, received considerable attention at the hands of European and American Bacteriologists within the last fifteen years.

With the exception of our Vandyke Carter's valuable and classic Monograph[2] on this disease, nothing of importance had been produced before that period.

In 1874 he published his work which was the result of observations carried on by him for over 10 years. A study of this work in the light of subsequent discoveries shows that these observations were absolutely correct.

Just as in the case of Malarial fevers three principal varieties were recognised long before the discovery of three different micro-organisms, *viz.*, those of Quotidian, Tertian and Quartan varieties, similarly in this disease—I may now say these diseases—three varieties were described according to the colour of the particles found in the diseased tissues. Carter was the first to demonstrate conclusively the existence of a fungus allied to the common moulds in the Black variety and he thought that the same may be sometimes demonstrated in the common White variety also. It is quite possible that he may have come across one of the rare White varieties from which an aspergillus has been cultivated.[3] He thought that a mould was responsible for the Red variety also. This mould found in the Black variety has been named after him Chionyphe Carteri.

Lewis and Cunningham[4] have, as a result of their observations, concluded that Mycetoma was a sort of local fatty degeneration of the tissues and that the existence of the mycelial structure in the Black variety was only accidental. This idea of local fatty degeneration of the tissues is an important one and I do not think that it has received the attention it deserves, and this will be referred to again at a later stage.

In 1886 Carter[5] published two cases of the White variety in the Transactions of the Bombay Medical and Physical Society; there he advanced the view that Mycetoma is at least closely allied to Actinomycosis if not identical with it.

Kanthack[6] in 1892 published his observations to prove that not only the White but the Black variety also was closely allied to Actinomycosis.

Some observations made by Sir Robert Boyce and myself[7] led us to advance the view that we have to deal with the existence of two distinct lowly organisms and that the White variety was characterised by the presence of a micro-organism of the Streptothrix variety, and that the Black particles contained a fungus allied to the common moulds. By means of decolorising agents we were successful in demonstrating the existence of the mycelial filaments of this mould in all the specimens we were able to examine including those of the Black variety which were examined by Kanthack. This is not only true in the case of preserved specimens but also in the case of fresh particles removed from sinuses. In fact every sample that I have examined has shown the same appearances. The mycelial filaments vary in thickness in some cases. The best means for bringing out the fungus is as follows:—Put the particle in a watch-glass and pour over it Hypobromite of soda, a solution which is used for urea estimation, for about 10 minutes, when evolution of gas takes place and the colour appears to fade at the periphery of the particle. Remove it from this fluid and dip it in distilled water when some more colour oozes out and the particle is ready for mounting in Farrant's solution.

We were to demonstrate this fungus not only in individual particles but also in sections of the tissues by means of embedding it in celloidin and decolorising the sectons with Eau-de-Javelle (a mixture of various Hypochlorites).

In the White variety we could never find this fungus which is highly resistent to the action of alkaline fluids, in fact the white particles when treated thus get completely destroyed and no definite structure can be made out.

[1] Cultivation of the Black Variety of Mycetoma. Dr. J. H. Wright. Journal of Experimental Medicine, Vol. III, page 421.

[2] Mycetoma or the Fungus Disease of India. Dr. H. Vandyke Carter.

[3] Huxley Lecture by Sir Patrick Manson. *Lancet*, October 3rd, 1903.

[4] Physiological and Pathological Researches. T. R. Lewis.

[5] Note on Mycetoma and Actinomyces. Dr. H. Vandyke Carter. Transactions of the Medical and Physical Society of Bombay, No. IX, New Series, 1887.

[6] Journal of Pathology and Bacteriology. No. 2. Dr. Kanthack.

[7] Upon the existence of more than one Fungus in Madura Disease (Mycetoma). Sir R. Boyce and Dr. N. F. Surveyor. Transactions of the Royal Society of London, 1894.

Under the microscope the black particles, when examined without any previous manipulation, show no definite structure; however, in very small particles with very little pigmentation there is a curious appearance of slight venation with round vacuole-like spaces imbedded in a structureless matrix of a rich golden brown colour. This pigment masks the appearance of the mycelial structure; however, one can gradually decolorise the particle by running either the Hypobromite of soda, or Eau-de-Javelle, under the coverglass when the true nature of the fungus is soon revealed. The round vacuole-like spaces are swollen parts of the mycelial filaments, sometimes they are terminal and under such condition appear like clubs of Actinomycosis. This appearance of clubs is best seen in slightly or not at all decolorised specimens. This fact is important because in exceptional cases of this variety the mycelial filaments are very slender and the appearance of the club-like swelling is apt to mislead one, especially in undecolorised specimens.

However, on gradually decolorising such a particle, one can at once see the septate and branching mycelial filaments, an appearance which is never seen in Actinomycosis.

The venation mentioned above is due to the mycelial filaments. No spores have been detected in any of these particles.

The big round cells were looked upon by Carter as sporangia, but never have I seen any spores inside them. I have seen such in some of these granules, but these vary so much in size that I do not think they can be described as spores. It is possible that these are degenerate cells only.

I have attempted to cultivate these particles in four cases of this disease on ordinary bacteriological media; however, I have never succeeded in getting a culture of the mould. In three of these other bacteria grew so abundantly that the mould could not be expected to grow after that, while in one case the black particles remained unaltered for weeks together till the nutrient media (even liquid) had dried up. However, I am glad to say that other observers have been successful in cultivating a mould which is blackish brown in colour and the nutrient medium on which it grows has been found to take up the colour also.

This variety is rather rare in Bombay as compared with the white variety, and recently I have not come across a case of this variety for over two years.

Sir Patrick Manson[8] in his Huxley Lecture mentions six different varieties of fungi and streptothrices as having been cultivated from these diseases.

From one variety of the black particles an Aspergillus was cultivated, while from a White variety another Aspergillus was cultivated as mentioned above. Inoculation experiments made by all the observers, whether with the particles or cultures, have shown that this fungus is not pathogenic for lower animals. I have put in the particles subcutaneously into monkeys, guinea-pigs and rabbits, the result was invariably a local abscess from which the black particles were expelled in a more or less unaltered form.

It grows in the human beings along the course of the lymphatics principally, in some cases it penetrates the blood vessels also, as was found to be the case in some of the specimens examined by us. In this respect it resembles another fungus which sometimes attacks man. I mean Aspergillus Pneumonomycosis. A case of this disease was described by Sir R. Boyce,[9] and he demonstrated the fungus penetrating the blood-vessels of the lungs. Muscles, fibrous tissue, and even bones are disintegrated by the growth of the black particles.

It does not spread to any great extent from the site of infection as compared with the White variety, and this character of the disease serves to distinguish it from Actinomycosis Hominis.

In the White variety we have to deal with a parasite of the streptothrix variety, and it was first pointed out by Carter in the paper[10] mentioned above that it resembled Actinomycosis Hominis to such an extent that probably the two diseases were identical; however, he was careful to point out the following points of distinction between the two diseases :—

> "On the affirmative side—their common chronic nature, primary local manifestation, local effects and destructive incontrollable progress; also their equally presenting a morbid element strictly peculiar; and their both seeming referrible to a cause extrinsic to the living frame. As divergencies there is the fact that Actinomycosis of man appears to be derived by infection from the bovine species, and that it exhibits a tendency to spread to the whole system: whilst, on the other hand, Mycetoma seems to be derived from the ground or from plants, is not known to attack the lower animals or to become disseminated throughout the body."

Both Actinomycosis and Mycetoma were at one time thought to be tubercular diseases on account of their resemblance to chronic tubercular joint disease. This is an interesting fact as later researches on the Tubercle bacillus seem to show almost certainly that the organism must be classed as a streptothrix and not a bacillus. It is now believed that in the animal tissues it undergoes some changes and takes on a bacillary form. Thus it seems that the older observers who looked upon the White variety of this disease as allied to tuberculosis were not very far from truth.

The White variety spreads much more freely than the Black one, still its progress is very chronic as compared with that of Actinomycosis, in fact I do not know of any observer who has found the internal organs attacked by it. Dr. Bainbridge[11] described a case in 1882 where

[8] Huxley Lecture by Sir Partrick Manson. *Lancet*, October 3rd, 1908.

[9] On "Aspergillar Pneumonomycosis" No. 2. Journal of Pathology and Bacteriology. Sir R. Boyce.

[10] Note on Mycetoma and Actinomyces. Dr. H. Vandyke Carter. Transactions of the Medical and Physical Society of Bombay, No. IX, New Series, 1887.

[11] Mycetoma of the Foot. Dr. G. Bainbridge. Transactions of the Medical and Physical Society of Bombay, No. II, New Series, 1883.

the lymphatic glands of the thigh and groin were invaded by the particles, the disease having started in the foot. Drs. Hatch and Childe[12] have published the case of a negro who had the knee-joint affected and the inguinal glands were found to have the particles also ; however, on making a *post-mortem* examination the internal organs were found free from these. The glands surrounding the iliac vessels were considerably enlarged but no definite particles were found. It is quite possible that the particles were very small, and, had smears of these glands been examined, perhaps a few streptothrix particles might have been found. But one thing is certain, that the internal organs were quite free from infection.

The fact that this disease does not attack the internal organs like the Actinomycosis parasite is not a very strong fact against similarity of the two diseases, because we know that the tubercle bacillus also behaves in a similar fashion ; thus in Lupus, although the seat of infection is so near the mouth and nose, one rarely finds the lungs affected. Same is true to a certain extent of tubercular disease of the bones and the lymphatic glands.

However, it is when we come to study the cultural characters of these two organisms that we are confronted with a fundamental difference. Thus the Actinomycocis Streptothrix is now regarded as an obligate anaerobe and the Streptothrix Maduræ requires oxygen for its growth. It grows very slowly on the ordinary nutrient media. Glucose-Glycerine Agar and Glycerine-Potatoe are the most suitable media for its growth; even on these it grows very slowly. In the variety cultivated by Vincent in Algiers he found the growth acquiring a slightly pinkish tint; however, in all the cultures I have obtained from the cases in Bombay this colour was never developed.

The specimen cultivated by Sir R. Boyce almost at the same time as the publication of Vincent's paper did not develop the pink tint also. This was a specimen obtained from our side of India, so it is probable that the variety found here varies slightly from that of Vincent's culture. Again other observers have obtained cultures which as they grow old show a whitish velvety surface. This is a character I have never obtained in my cultures even when they were so old that the nutrient medium had quite shrivelled up. The growth as it appears on Glucose-Glycerine Agar may be described as minute white colonies with a pin-point depression in the centre ; as the colonies get larger in size fine radiating streaks run from this point to the periphery. The growth is firmly adherent to the nutrient medium at the margins, while the central part is loosely attached. When manipulated with a platinum needle it is found to be brittle and it is difficult to make a good smear on a slide. It stains well with the ordinary aniline dyes and it is Gram positive. It gets readily decolorised with acids when stained with Carbol-Fuchsine. It is not pathogenic for the lower animals. Inoculation of the particles from the diseased part or of the culture produces a local abscess which soon opens and heals up. When introduced into the peritoneal cavity of a rat the particles were found to have disappeared completely. On account of the similarity of this disease to Actinomycosis inquiries have been made amongst Veterinary Surgeons for the existence of a similar disease, but without any definite result. During the wet season the horses in Bombay suffer from a growth which is called Kankir or Barsati. This is characterised by a chronic ulcer on one of the extremities from which white calcareous particles are discharged. The ulcer heals up on excision ; however, it recurs during the next monsoon. These particles were examined by me some years ago when I failed to find any structure resembling the mycetoma particles. In this disease the lungs are said to be secondarily affected, so it is probably due to some parasite. Recently I think I read somewhere that this is a disease similar to the Oriental sore and that bodies like the Leishman-Donovan parasite have been found in it.

Now I come to the consideration of a query which must occur naturally to one who has studied the Black and White varieties. How is it that two totally different organisms could produce almost identical pathological changes ?

The only apparent difference that is noticed between the two is the colour of the particles.

I think the correct answer to this is a denial of the statement that the pathological changes are identical. Anyone who has handled the specimens of both varieties will recall to mind the fact that in the White variety there is much more swelling and fatty degeneration, especially the latter ; in fact it was on examination of several cases of this variety that Lewis and Cunningham[13] seem to have arrived at the conclusion that this disease was nothing else but a fatty degeneration of the tissues in which low organisms found a suitable nidus. This fatty degeneration of the tissues is not characteristic of the Black variety to any appreciable extent—rather the reverse ; in this variety there is some wasting and shrivelling of the tissues. Specimens of the White variety, when put up in spirit, show globules of fat floating on it after a few weeks ; while in the Black variety I do not remember to have noticed this fact. In the Black variety one does not find any crystalline deposit at the periphery of the particles like what one finds in the White variety. These crystals are partly fatty in nature as was pointed out by Lewis and Cunningham and partly due to some mineral salts, perhaps phosphates, because one sometimes finds them even in sections which have been treated with fatty solvents like Ether, Alcohol, Chloroform, etc.

In the White variety I have seen whole muscles converted into bags containing fatty purulent matter in which crowds of white granules were floating.

As regards the microscopical appearances of the white particles I may state that often the particles are very minute and fail to show any radiating filaments round the central densely packed streptothrix filaments. Such

[12] A Remarkable Case of Mycetoma. Drs. W. K. Hatch and L. F. Childe. *Lancet*, December 1st, 1894.

[13] Physiological and Pathological Researches. T R. Lewis.

particles, however, when teased out in a little water and smeared on a slide show beautiful mycelial filaments of the streptothrix. No spores have been noticed in these filaments; however, in some specimens one comes across slightly bulbous swellings either in the middle or at the apex of a filament. I have stained such filaments with Möller's method with a view to see if any spores could be detected in these swellings but without any positive result. For seeing these filaments the best method is to tease a fresh particle and stain it with dilute Carbol-Fuchsine for about a minute. In preserved specimens these filaments do not come out nicely as the preservative renders them brittle and only a few short broken filaments are noticed in a granular debris which takes up the stain deeply. In sections this central mycelial structure is not often made evident as it is very densely packed; however, in some specimens shown by Prof. Hewlett we were able to see the central mycelium distinctly. As a rule only a densely packed reniform body, with radiating filaments studded with leucocytes, is seen in sections.

In the Black variety the mycelium does not take up any of the aniline dyes. Prolonged staining with Hæmatoxylene succeeds in imparting a faint blue tinge to the filaments, especially at the extremities which are sometimes deeply stained.

As regards the treatment of the White variety at least I may take this opportunity of suggesting that in early cases perhaps vaccine treatment will give good results, on account of the tendency of the disease to run a prolonged course and the close resemblance between the organism of this disease to that of tubercle. Tuberculine treatment has given better results in local chronic conditions than in the relatively acute infection of lungs, etc.

Some observations are being made by me on a case of this disease with injections, in the affected part, of Picrate of Soda; there appears some lessening of the inflammation and swelling and the discharges appeared to be lessened, but it is not certain whether the improvement will continue; failing this, vaccine will be prepared and I hope this will give a better result.

Of the Red variety I have no personal experience; I have even heard sceptics denying the existence of this variety, but I have an all-abiding faith in our Carter's accuracy and trust that I shall come across a case one day.

ON MYCETOMA.

A Brief Study of the Subject from its Clinical, Pathological and Morphological Aspects.

By J. EUGENE BOCCARO, L.M. & S.,

Civil Surgeon, Broach.

Close upon half a century has elapsed since Dr. H. Vandyke Carter, of honoured and esteemed memory in this city, first announced to the scientific world the fact that the disease which forms the subject of this paper was essentially of fungal nature and origin. Subsequent investigations by others have greatly tended to favour this view, and more recent evidence on the subject within the last twenty-five years or so have by the aid of advanced modern bacteriological methods fully confirmed the fungal character of the disease. But this is all. Beyond this point many important and interesting facts connected with the malady remain still afloat in a sea of doubt and uncertainty. Perhaps no better testimony to this circumstance exists than that afforded by the British Nomenclature of diseases itself.

In the first, or 1866, Edition of this document, mycetoma, classed under the head of disease due to Vegetable Parasites, is described as follows:—

> 873. Mycetoma. Syn: Madura-foot. Parasite, Chionyphe Carteri.

In the next, or 2nd Edition (First Revision), 1885, *i.e.*, 10 years after the publication of Carter's Monograph on Mycetoma, the malady is described thus:—

> 124. Chionyphe Carteri. Definition—A cotton fungus occurring in the disease called mycetoma. Habitat—Deep tissues and bones of the hands and feet.

In the next decade several important contributions were made to the literature of the subject. Kanthack (and also Hewlett), in 1892, recognized mycetoma as being identical with actinomycosis. Vincent, in this same year, demonstrated the existence of a Streptothrix form, distinct from Actinomyces, as the causal agent in the white type of the disease. Boyce and Surveyor, 1892-94, independently of Vincent, concluded from their investigations that the white variety was due to the same or a similar Streptothrix and the black to a Hyphomycete. About this same time, from a clinical study of the subject, I noted the fact that the disease was found to attack not only the hands and feet but also other parts of the body, and pointed out that the term madura-foot was, therefore, a misnomer. In the 1896 or 3rd Edition (Second Revision) of the Nomenclature, mycetoma is now described thus:—

> 33. Chionyphe vel. Streptothrix Carteri. Occurs in the deep tissues and bones of the hands and feet in mycetoma or madura-foot.

And in the 4th Edition, 1907 (Third Revision), a further alteration is made, and the description given is as follows:—

> 32. Streptothrix Maduræ. Syn. Chionyphe vel. Streptothrix Carteri. Actinomyces Maduræ. Found in the soft tissues and bones of the hand and foot in Madura disease or myce-

toma. This malady is likewise classed among the Infective Diseases.

Since the more recent published investigations, 1907, such as those by Wright and by Musgrave and Clegg, matters are made doubly doubtful as to which is the true infecting fungus in mycetoma. Are then, the fungal forms previously discovered by Boyce, Vincent, and others, distinct and independent species, or are they phases of one and the same fungus? Is mycetoma a true streptothricosis, or a modified form of actinomycosis, or is it argillosis of a localized form? Is it an infective disease in the sense that germ diseases are, or are its manifestations always local? Does the disease attack invariably the external sub-integumental tissues only, or is it sometimes found to attack the internal sub-mucous tissues also? Is the organism a cotton fungus, if not, what is its habitat in natnre? These are some of the more important questions regarding which we are, as I have said, still in a sea of doubt and uncertainty.

The importance of the present form of description of the disease as given in the Nomenclature is obvious. The disease has now secured for itself a local habitation and a name. We are in a position, therefore, to define the malady, and I shall venture to set forth the definition thus: *Mycetoma is an infective disease caused by the agency of a parasitic vegetable organism, and characterized by the formation of a tumour-like growth as the result of certain morbid changes excited by the parasite primarily in the superficial soft tissues beneath the integument, and subsequently in the deep, soft and hard tissues of the human body.*

It will be noted that I have in this definition attributed the causal agency to a single parasite for both types of the disease, and my reasons for doing so will be found discussed in a subsequent part of this paper. And in characterizing it as *infective* I have anticipated the possibility of the disease being a form of argillosis.

The Distribution of Mycetoma in India.

From the limited materials available on the subject, I have endeavoured to map out roughly the districts where mycetoma is found prevalent in a greater or lesser degree. The accompanying map shows the endemic localities, and it will be apparent from it, at a glance, that the disease extends over a considerable area of this country within districts which, seen from a broad point of view, are in close, if not direct, geographical connection with one another. Moreover, from the fact that the wide tract of country invaded lies in different latitudes, it is clear that neither topographical nor climatal conditions in themselves are factors which favour the development and growth of the fungus. On the other hand, it will be gathered from the following description of the incidence of the disease in India that the general physical features of the affected districts as regards terrestrial humidity and a certain degree of high, but not too high, atmospheric temperature, appear to furnish conditions favourable to the growth of the parasite.

Having, in course of the study of the subject in hand, noticed the curious coincidence that the endemic areas of mycetoma, such as I have been able to delimit, correspond in the main with two of the six botanical regions of India as indicated by Major Prain in his "Plants of Bengal" (Introduction, p. 2)*, it strikes me that it would be most instructive for a comparative study of the geographical distribution of mycetoma to recapitulate here in full Major Prain's regional classification of the Flora of India.

It is as follows:—

India Deserta.—Sind, Rajputana, and the Punjab. (The Indus Plain Region.)

India Diluvia.—With its chief development in the Gangetic plain, comprising much of the territory that constitutes politically the United Provinces and Bengal. (The Gangetic Plain Region.)

India Aquosa.—The wet forest tracts along the Western Ghats from Gujerat to Travancore which receives all the force of the South-West monsoon. (The Malabar Region.)

India Vera.—The dry but not desert triangle between the Western and Eastern Ghats of the Peninsula with its apex in Tinnevelly and its base skirting the Gangetic Plain. (The Deccan Region.)

India Sub-Aquosa.—The Eastern Ghats and the strip between them and the sea. (The Coromandel Coast.)

India Littorea.—Most highly developed in the Gangetic Delta. (The Sunderbans Sub-region.)

In respect of these several regions it may briefly be stated that mycetoma is found to exist in India Deserta and in India Vera mainly, and practically is almost absent in all the other regions detailed above. Of the two regions just mentioned, the former, it will be observed, comprises the tract of country to the west of the Aravalli Range, the true Indus Plain, and in this region, in addition to the Punjab, Sind, and Rajputana, Hooker very properly includes Cutch, the northern half of Kathiawar and Northern Gujerat, inasmuch as these parts are, as regards their main physical and botanical features, closely allied to Sind and the lower Indus Plain generally.

The coincidence mentioned above is rendered still more striking when we come to note the fact that, in conformity with the approximate sameness of the flora appertaining to these latter parts of the country with that of the Indus Plain region, as pointed out by Hooker, strangely enough, as is evidenced by the circumstance that mycetoma is largely prevalent in this vast district, the fungus (or fungi) causing the disease is likewise found to luxuriate within precisely the same botanical limits.

In a detailed study of the region described as India Deserta, it is noticed that the districts on the Western banks of the Indus, especially in the Nothern parts,—Dhera Ismael Khan, Dhera Ghazi Khan, Jacobabad,

* *Note.*—Quoted by Hooker in the Imperial Gazeteer of India, the Empire of India, Vol. I., p. 164.

Shikarpur, Larkana,—where the condition of extremes of temperature is so well marked, mycetoma is found to be altogether absent or at most exceedingly rare; on the other hand, along the Eastern banks and over the sandy plains of Western Rajputana, the disease is prevalent in a marked degree. In this latter area, with Hyderabad (Sind) district as a conspicuous focus of endemicity, the plain of infection may be described as extending north-eastwards across the Thar or Little Desert, through the Great Desert,—Jesalmer, Bikaner, and Bhawalpur,—to the lower Punjab into the plains watered by the five rivers and which comprise chiefly the districts of Multan, Lahore, Amritsar, and Ferozepur. From this seat the endemic area may be traced downwards through the Patiala State to Delhi, with a well-marked focus of prevalence around Delhi in the districts of Rohtak, Hissar, Rewar and Alwar, until it reaches the extreme north of the Aravalli hills, below which point, namely, in the districts of Agra, Jeypur and Gwalior, cases of mycetoma progressively decline to the minimum.

Within this same region (India Deserta), as demarcated by Hooker, there lies yet another infected tract of country, namely, that extending from the Runn of Cutch—Cutch—Bhuj—Westwards through the Northern Kathiwar—Nawanagar, Morvi, Gondal, Rajkote,—and the uppermost part of Northern Gujerat—Patri, Patan, Palanpur,—towards Indore and Bhopal in Central India, to the foot of the Vindhyas range of mountains, where the disease is almost absent. In the districts immediately to the south of the Vindhyas mountains, and in the valley of the Narbada, mycetoma, strange to say, is found not to occur.

It will be seen from the map that, within the limits of the whole region termed India Deserta, there exist several scattered spots of high prevalence of the disease, as for example Cutch, Nawanagar, Hyderabad (Sind) district (including Mirpur Khas), the lower Punjab, and the districts around Delhi. For want of any data based on actual investigation, it is impossible to account for the existence of these specially localised seats of the disease, but what suggest themselves as being the probable dominant factors in the formation of local foci of prevalence are, on the one hand, terrestrial humidity due to such causes as back-waters, floods, the existence of swamps, marshy lands, and extensive pools of stagnant water, and on the other, a contributory physical influence exercised upon the growth of the fungus by a lower atmosphere of comparative warmth and dryness.

We now come to the consideration of the botanical region termed India Vera. The distribution of mycetoma in this (the Deccan) Region, occupies, among others, the important and well known district of Madura. Within this region the area of incidence of the disease coincides largely with the low-lying tract of country on the Deccan Plain, including the southernmost limits of the great Gangetic Plain Region; and herein too, some well-marked zones of accentuated prevalence of the disease is noticeable. In Madura and the adjoining districts of Tinnevelly and Palamcotta to the south, and Coimbatore to the north, districts lying in the southernmost part of the Madras Presidency near the angle of the great plateau where the Eastern and Western Ghats approach each other, and which are described as being exceptionally hot and arid, mycetoma is common. Proceeding northwards from this point, it is noticed that in Trichinopoly the disease is comparatively rare; in the hilly districts of Salem, it is all but absent; so also in Chitor; but cases, in rare instances, are to be met with on the plains on either side of the foot of the Eastern Ghats in the districts of South and North Arcot, on the Madras side, and the eastern limits of Mysore territory on the Deccan side.

A little further north, in the low-lands in and around the valley of the Kistna, both before and after this river crosses the Eastern Ghats on its way to the Coromandel coast there lies an area of moderate prevalence of the disease, comprising the districts of Cuddapah, Anantapur, and Bellary as far eastwards as Guntur and Vizianagram in the Madras Presidency, and westwards, in slowly fading prevalence, to Gadag and Dharwar in the Bombay Presidency. But the area of infection within the reaches of the Kistna does not terminate here. On following the up-stream course of the river along its chief tributary branch, the Bhima, mycetoma is found to exist, though not to any great extent, also in Bijapur, the Jath and Akalkote Native States, Sholapur, Poona, and Ahmednagar.

Northwards from the valley of the Kistna, we come across an extensive tract of country watered by the Godavari and the Mahanadi, the basins of both which rivers appear to present here and there in seemingly widely separated centres local conditions (whatever these local conditions might be) favourable to the development of the disease, or, in other words, to the growth of the fungus (of mycetoma). Although no localised areas of endemicity are to be found anywhere in the whole of this latter tract, yet, in point of extent of infection, the area covered is by no means a small one, especially so, if within this tract are included the delta of the Hughli, the southernmost limits of the lower Gangetic Plain and the valley of the Tapti, since cases of the disease, albeit occurring at fairly long intervals, have been reported likewise from these several parts of the country. In the whole area of infection here indicated the incidence of the disease would seem to assume a sporadic form, unless, indeed, it be that the cases are in reality imported cases, though it must be admitted that there are not sufficient reasons forthcoming in all cases in support of this alternative hyphothesis. Such sporadic cases, occurring at intervals of from two to ten years and more, have been reported from various centres in places which are not in direct geographical connection with one another. Viewing this tract from East to West the places so affected are as follows:—Alipur and Chinsura (Hughli) in the 24 Perganas; Sambalpur, Nagpur, and Amraoti in the Central Provinces; Akola district in the Berars; Bhusawal, Jalgaon (East Khandesh); Nandobar, Dhulia (West Khandesh); and Surat and the Tapti Valley.

In the southern parts of Gujerat, mycetoma is exceedingly rare, the few cases seen at long intervals in the Civil Hospitals of Ahmedabad, Kaira, and Broach, being in most instances, imported cases. In the United Pro-

vinces, Central India, and in the northern parts of the Central Provinces, the incidence of the disease is inappreciable. In the following parts of the country mycetoma is not known to exist, namely, in Northern Bengal proper, and East Bengal, on the whole of the Western coast line from Karachi to Cape Comorin, also in the narrow strip of the sea-face country from Tuticorin northwards to Ganjam ; and, so far as report goes, the disease is unknown in Assam and Burmah.

In connection with the subject of the distribution of mycetoma, it might be of interest, with reference to the etiology of the disease to note the fact gleaned from enquiry that where mycetoma is found there the Acacia Arabica (Babul) forms an important feature in the vegetation of the district, but not so the cotton plant. On the other hand it must be stated that there exist wide tracts of country where the Acacia grows more or less plentifully and cotton is cultivated abundantly but where mycetoma may be said to be conspicuous by its absence. These facts do not seem to bear out the suggestion that the fungus of mycetoma is parasitic on either Acacia or cotton plant, but at any rate it seems probable that the thorns of the Acacia not unfrequently act as agents for the conveyance of the mycetic elements into the human body through injuries caused by them.

In the enquiry into the incidence of mycetoma in India another important and interesting point is brought to light, namely, that as regards the relative distribution of the two prominent types of the disease, the black and the white. The information at hand shows that both varieties are invariably found located within the same endemic area of infection; that, as a rule, the black variety always predominates in number ; but that in certain infected localities, as compared with others, there is found, within limited zones, a relatively higher proportion of cases of the white variety. This is the case, for example, in Madura as compared with Hyderabad (Sind), or Palamcotta and Bellary as compared with Madura. But, indeed, on contrasting the incidence of the disease within the two regions, India Vera and India Deserta, each as a whole, there is observed a similar relative numerical proportion between the one type and the other, that is to say, that whilst the black variety outnumbers the white in both regions, the white type of the disease is found to maintain a higher range of frequency of occurrence in the former region than in the latter. It must be here noted, however, that this assertion is based merely on general information and not on actual figures, as statistics showing the incidence of mycetoma throughout each of the two abovementioned endemic regions are not available. It is difficult at the present stage of investigation to account for this difference in the incidence of the two types, but it is possible that it is only due to local favourable conditions of growth of the parasite. However, the fact of the co-existence of the two types within the same endemic areas is well-worthy of special note as this contingency would seem to indicate a possible organic co-relationship between the micro-organisms of the respective types, a point which will be found discussed below as fully as is possible within the limits of this sketch.

Morbid Anatomy and Pathology.—Mycetomatous tumours are found to exist under two distinct forms, capsular or local, and non-capsular or spreading. The former is characterized by the presence of an investing fibro-membranous capsule which apparently serves to check the fungal growth from expanding *ad libitum* and thus localized tumours are formed, whereas the latter is marked by the absence of any such investment and as a consequence the parasitic growth is able to invade, without let or hindrance, the normal structures surrounding it, with the result that an extensive and almost unlimited expansion of the lesion takes place giving rise eventually to the unique massive tumour so commonly seen.

Capsular tumours are always lobulated in appearance and, as a rule, superficial, being generally located in the subcutaneous areolar tissue, but, in a few cases, they may be found lying deep in the intermuscular or in the interosseous connective tissues. Estimated on statistics collected for Sind, they seem to occur in about 10 per cent. of all cases within an endemic area, the relative proportion between black and white varieties being about 9·5 per cent. of the former to ·5 per cent. of the latter. Capsular tumours of the white kind are, therefore, it will be observed, exceedingly rare. In either variety the cysts are always multilocular or compound.

The morbid lesion caused by both forms is practically the same, with this difference that in the capsular there is, as a rule, much of displacement and but little of disintegration and absorption of the normal tissues, a condition of things found to be exactly the reverse in the case of the non-capsular form. Hence it may well be said that progression of growth in capsular tumours takes place by dislodgement of the obstructions it meets, and in non-capsular growths by their actual obliteration.

In both forms the path followed by the parasite is invariably through textures normally rich in fat, namely, the subcutaneous areolar tissue and the intermuscular and interosseous cellular tissues, so far as capsular tumours are concerned, and in the non-capsular form, in addition, the deeper fat-containing tissues are attacked, namely, muscle substance and, through minute openings in the bony crust, the cancellous tissue and the marrow of bones. Tendon, ligament, cartilage, and hard bone tissue are, likewise, in due course, involved in the lesion, so that, finally, all these normal anatomical structures are destroyed, absorbed, and replaced by a homogeneous mass of hypertrophic tissue replete with tunnels and cystic cavities containing the mycotic elements, black or white as the case may be. Blood-vessels, lymphatics, and nerves are, of course, also invaded by this adventitious growth, and share the same fate as the tissues above-mentioned. In the near vicinity of the lesion, the veins are found generally somewhat dilated, the arterioles and lymphatic vessels either contracted or altogether destroyed, while the muscles in the neighbourhood are rendered anæmic, thin, and atonic. But what is a very noted feature in the morbid character of the parts actually attacked

by the parasite is the marked bloody oozing which follows incisions made into these parts on the operating table, and which indicates the presence therein of an extraordinary large amount of capillary vessels. Another noteworthy phenomenon is the occurrence of oily matter in great abundance in the midst of the infected tissues, giving the cut surface of the tumour a greasy appearance. Outside the limits of the lesion, however, adipose tissue shows no tendency towards such fatty disorganisation. This fatty condition is equally conspicuous in both varieties of the disease, but, in the case of the white variety, fat in the crystalline form is, in the main part, common, whereas in the black it is found to occur mostly in the liquid state.

Hitherto this phenomenon of the fatty metamorphosis just described has been looked upon as a pathological expression of the disease only, but I am disposed to believe that it is something more—in fact, that it is the result of a physiological function connected with the growth and development of the fungus ; in other words, that the destructive process of the normal fatty tissue is, in reality, a constructive process in the manufacture, so to speak, of the pabulum needed for the nutrition of the parasite. Now, culture experiments have shown that the fungus is an aerobic organism, the method of existence of the fungus in the human body beyond the reach of ærial influence has, therefore, to be explained. The explanation appears to be that the fungus in its human host lives and breathes by the process of what mycologists call "intramolecular respiration," by which is meant the functional power which Fungi possess of exhaling carbon-dioxide in an atmosphere deprived of oxygen. This process is necessarily closely connected with the medium of nutrition of the fungus, and it demands that the nutritive substance must be a substance capable of undergoing fermentation. Fat being undoubtedly of such a nature, the metamorphosis which adipose tissue undergoes in mycetoma is, I therefore conclude, the resultant effect of a chemotactic influence exercised by the fungus upon the organic tissues in which it vegetates, the special object being that of securing for itself the needed elements for its nutrition and respiration. Further, it is a known fact in the case of plants that the mycelial hyphæ of many fungi vegetating as parasites on such parts of the host-plant as are deficient in chlorophyll, or where chlorophyll is entirely wanting, take up their carbon from the carbonaceous compounds of the organic matter on which it vegetates. This latter phenomenon, though not as yet, as far as I am aware, shown to exist in connection with animal parasitism, may, nevertheless, it appears to me, be a possible feature of the fungal parasitism in mycetoma. In this connection, I would invite your attention to Dr. Allan Macfadyen's very interesting contribution to the biology of the ringworm organism,* as the article suggests many useful points which seem applicable to the mode of biological existence of the fungus of mycetoma.

Viewed from a physiological standpoint, the fatty metamorphosis observed in the tissues in mycetoma helps to elucidate certain important considerations in connection with the disease. For example, it explains how and why the fungus attacks and destroys the various tissues in the human host, the manner in which it grows and thrives there, the nature and source of its food-supply, no less than it renders intelligible the facts of its local manifestation, its chronicity, and the peculiar hypertrophic enlargement characteristic of the disease. To the latter phenomenon DeBary has, in relation to plants, applied the term "mycetogenetic metamorphosis," and he states that "these mycetogenous deformations are in direct causal connection with the process of feeding the fungus."

The evidence derived from artificial culture of the organism likewise seems to support the theory that adipose tissue furnishes in itself the proper food-material for the fungus of mycetoma, inasmuch as it is noted that cultivation is most luxuriant in carbonaceous media, such as glycerine-sugar-agar, potato, vegetable infusions, &c., whereas in nitrogenous media, *e.g.*, bouillon, blood-serum, egg, &c., the development is, as a rule, very scanty, if not doubtful.

The characteristic hypertrophic enlargement above referred to appears to be the highest stage in the morbid growth of the tumour, as beyond this point necrotic foci begin to show themselves and multiple abscesses of very minute size to form within the seat of lesion. This enlargement is, in the main, apparently due to the nutritive adaptation of the parasite, and, in part, only to a chronic inflammatory condition of a very limited nature. Section of any part of the hypertrophied region exposes to view numerous minute cystic cavities with fine canaliculi radiating from them, and in these spaces are found located the mycotic elements of the disease, the sclerotia occupying the cysts and the mycelial offshoots the tubules.

The ordinary trend of the parasitic growth in mycetoma appears to be that common to most forms of filamentous fungi, namely, to extend indefinitely by ramifications into the tissues of its host, so long as the supply of pabulum of the proper kind fitting its development is available. That such is the case is sufficiently well indicated by the fact clinically observed that the tissues are attacked *per continuatatem*, and the fact that the track pursued is, as already pointed out, invariably along the fat-laden routes in the tissues of the host, the fatty elements helping to provide the necessary food-material. The direction sought by the growing filaments, it is observed, is generally that towards the central circulation.

The morbid changes occurring in the cutaneous tissues are precisely the same as those in the deep soft tissues, I mean so far as the changes produced by the growth and expansion of the fungus itself is concerned, there being seen in the former the same hypertrophic enlargement, the same formation of cysts and tunnels, and, finally, of sinuses as in the latter. Further, it may be observed that in the cutaneous lesions the fungus shows no special advancement of morphological

* Journal of Pathology and Bacteriology, Vol. III, 1896.

growth as indicative of maturity of development, no formation of reproductive bodies, spores, or sporophores, and no signs of decadence of the fungal elements in proof of completion of its vegetative life; and from these facts one is led to infer that the contained fungal structure has reached the surface of the body, and found exit there, not by virtue of any natural law concerning the life or death of the fungus, but purely as a matter of accident.

What changes take place primarily in the normal tissues beneath the integument at the first entrance of the spore or the mycelium, whichever it be, into the human host, it is obviously difficult to say; but, to judge from the macroscopical and microscopical appearances of the lesion at later stages of infection, the probabilities are that the presence of the fungal elements in the tissues excite an extremely local subacute inflammation, limited, in fact, to the contours of the mycelial filaments, in virtue of which a protective gelatinous coat is formed around them as they grow, and expand within the host from the substratum. Between and around the fungal structure some sort of tissue-metamorphosis takes place, for, as seen in early growths that have come under my observation, there is already present a mass of granulation tissue making up the chief bulk of the fungal tumour. Then, apparently, there comes a time when the terminal ends of the tubule containing the mycelium broadens out to form a minute cystic cavity as a preparatory step, as it were, for the reception of the so-called "fungal particle," the sclerotia, black or white, such as are seen to subsequently issue from the sinuses.

What is now observed under the microscope is a group of round cells encircling the fungal hyphæ, which are held together by a delicate net-work of fine blood-vessels, the cells being located in the meshes of a fibrillar, transparent, reticulated substance. On the inner side of the group of round cells, between them and the central hyphal mass is a collection of finely granular debris, and on the outer side, in most preparations, may be seen large nucleated cells, giant cells, and phagocytes. In the soft gelatinous mass in which the fungal particles are found suspended there appears in both varieties, even at this early stage, granules of pigment varying in colour from pale yellow to dark brown and black, also of crystallized fat, together with fat-cells in various stages of disintegration. With time typical granulation cells appear around the fungal body which now has begun to show its special morphological features, namely, clubbed rays in the white form of the disease and filaments of cellular formation in the black. Then the granulation cells, it is evident, are converted into fine interstitial tissue, which, from being pressed upon by the further growth of the fungal mass, is rendered more or less compact, presenting somewhat a striated appearance and, finally, is converted into fibrous tissue.

In course of time, as the tumour advances and attains a certain extent of overgrowth, a time arrives when, irrespective of its size or bulk, either owing to exhaustion of nutrition, or to spontaneous degeneration, or perhaps to both, disintegration of the whole or part of the fungal contents of the cyst takes place, and now pus cells appear in the midst of the hyphal mass, and together with pus the detritus of broken-down red blood-corpuscles, which latter often produces a pigmentation of the lining membrane of the cysts and tunnels. These elements of putrefaction are eventually eliminated through the sinus or sinuses found in connection with the growth itself, and by which the fungal particles also effect their escape to the surface. Putrefactive changes, it appears to me, are not a necessary accompaniment to the growth-development of the parasite.

The *black* particle, examined under a magnifying power of $\frac{1}{12}$ oil immersion, is seen to be composed of a central more or less dense tangled tuft of hyphæ with numerous eccentrically branching septate or moniliform filaments, which, however, do not, as a rule, appear to follow any definite distribution. The cells composing the hyphal filaments vary considerably in their size and density, as also in their septate arrangement. Fusion or coalescence of the cell-segments of some of the ramifying branches within the central tuft is noticed, but whether only apparent or real by actual cementation is not known. No spores or sporangia are seen at the terminal ends of the filaments. The growth of the filaments, it is observed, takes place by tube-germination, the process common in all forms of sprouting fungi. The branching of the hyphæ sprouting from the terminal cell-segment takes place from lateral budding and is not dichotomous. The growth is evidently, therefore, a hyphomycete, and coming as it does under the category of "fungi imperfecti" the probabilities are that, like many of these forms of fungi, it is one of the phases in the life-cycle of the species to which it belongs. Whether or not the species is the Streptothrix Maduræ of Vincent, or the Streptothrix Freeri of Musgrave and Clegg (I shall refer to these forms presently), or some other known or unknown species, is a matter demanding still further investigation.

The *white* particle under a magnification of 300 to 500 diameters is seen to be made up mainly of a central body composed of a tuft of indistinctly outlined fibrillar elements embedded in a mass of finely granular substance, fenced round, partially or completely, by a palisade of straight cellular elements of varying shape and size. Under rather high magnifying powers, 1300 to 1500 diameters, the structural elements observed in the granules disclose the existence of a highly organised form of vegetable parasite, one of the Streptothrix group to which the ray fungus of Actinomyces also belongs, and which it closely resembles morphologically, but differs from it in several other important technical points. The radiating filaments which constitute the so-called rays vary considerably in shape and size, some of the rays being short and stumpy, and others long and delicate. Kanthack describes them as being in most instances distinctly clubbed as in Actinomyces, and he states that the rays are directly continuous with the filaments of

the central tuft. Boyce and Surveyor, as well as Vincent, demur to the existence of *true* clubs as also to the fact anent the intra-radial continuity of the mycelial threads. The terminal expansions of the radial filaments give no evidence of any distinct spore-formations, either spores or sporangia.

Experimental bacteriologists have, during the last few years, thrown much light on the subject of the nature of mycetoma, but though the net results of these investigations indicate a complete agreement as to the fungal origin of the disease yet they have given rise to considerable divergence of opinion as to the specific nature of the infecting parasite, more especially as regards the white or ochroid variety. In this short paper I can do no more than place before you a brief resumé of the results of these experimental researches, referring you to the original articles of the writers concerned for a detailed description of the various points of interest connected with the experiments.

Among the older investigators it is necessary to mention the results obtained by Dr. Vandyke Carter inasmuch as the more elaborate and precise researches of latter-day experimentalists rather tend, in some ways, to uphold than to subvert the views of that distinguished microscopist. The results of the most prominent investigators, reviewed in a nut-shell, are as follows :—

Carter.—1860-1874.—One specific vegetable parasite, the Chionyphe Carteri, common parent of both types of the disease, the *melanoid* representing the advancing, the *ochroid*, the stationary stage of the growth.

Kanthack.—1892.—One specific parasite, the ray-fungus allied to, if not identical, with Actinomyces : Oospora Indica, as he calls it, common parent of both types of mycetoma, *ochroid* being the advancing, the *melanoid* the final or mature stage.

Boyce and *Surveyor*—1892-1894.—Two distinct parasites, one for each variety, a ray-fungus, a species of Streptothrix, different from Actinomyces, in the *ochroid*, and a mould, probably belonging to the Hyphomycetes order of fungi, in the *melanoid.*

Vincent.—1892.—A ray-fungus, distinct from Actinomyces, the Streptothrix Maduræ, as he names it, in the *ochroid* variety. *Melanoid* unknown, not being investigated by him.

Wright.—1907.—The lesion in the *ochroid* variety, a true actinomycosis, in the *melanoid* due to a Hyphomycete.

Musgrave and *Clegg.*—1907.—The *ochroid* type due to a new species of Streptothrix which they call Streptothrix Freeri, distinct from S. Maduræ of Vincent and from Actinomyces. The *melanoid* type, according to them, is due probably to Wright's Hyphomycete.

The state of affairs, as shown in the results of the investigations of the several experimentalists mentioned above, places us, so to say, in the strained and anxious position of spectators and speculators in the Derby race. Which micro-organism shall win ? Or will the honour and glory of the contest be finally claimed by a 'rank outsider'? The questions so tersely put by Sir Patrick Manson, Are the two types, the ochroid and melanoid, caused by the same parasite, by varieties of the same parasite or by distinct species ? must, therefore, I fear, still remain unanswered, pending further microscopical discoveries and cultural revelations. Until, however, artificial cultivation and inoculation experiments are successfully made to the full satisfaction of Koch's canons, one is compelled to maintain a sceptical attitude. But so far Musgrave and Clegg's organism may be regarded as the prime favourite, to follow up the racing metaphor, and with good reason, for, in its case, reproduction of the disease in animals by inoculation with the culture-product has been successfully accomplished. But were I asked if I were prepared to back the favourite or stake my interest upon an outsider, I should say, I would, for the time being, do neither. I should prefer to await further developments for the reason that even to the present day so little, indeed, is known of the general life-histroy of the different forms of parasitic fungi, and still less of the microscopic forms, as to render caution necessary, for who knows but that this very Streptothrix form may after all be simply a polymorphic phase of, say, an ordinary Aspergillus. This is neither a novel nor an impossible view, which is as much as I can at present adumbrate on the subject. But I must not fail to remind you that in this circumstance lie the chances in favour of the 'rank outsider.'

The conflicting results as mentioned above obtained by modern investigators give rise to two very important considerations in connection with the etiology of the disease, firstly, they seem to suggest the possible existence of more than one species of streptothrix in the ochroid variety, thus pointing to mycetoma being essentially a form of streptothricosis, and, secondly, they appear to support the view that the ochroid and melanoid types are not identical in nature, or in other words, that there exists no morphological co-relationship or organic continuity between them.

Time and space do not permit of a detailed statement of facts opposed to this latter view, but it is enough to say that there are certain important clinical, macroscopical, and microscopical features in the disease which seem to indicate that the fungi in the two types of the malady are in some way in their life history intimately connected with each other.

The attempt to throw more light upon this vexed subject of the organic continuity between the two organisms leads me into the domain of the mycologist and lands me into matters based purely on conjectures. But even a conjectural explanation may perhaps be of some use if it at least helps us to fit in correctly the chief and most important clinically observed facts with the phenomena of the progress of growth and development of, and the morbid changes effected by, the infecting parasite.

With this view I beg leave to draw your attention to a phenomenon of great interest connected with the spread

of fungal disease in plants, which if associated with mycetoma may possibly furnish a clue to the unveiling of the mystery surrounding the question of identity of the two types of the disease.

The phenomenon alluded to above refers to a peculiar character in the life-history of some of the higher forms of parasitic fungi as manifested by the recently discovered method exhibited by them of infecting plant-tissue with disease not only by the direct aid of spores, the manner hitherto commonly accepted, but also indirectly by means of *hibernating mycelium*, the outgrowth from sporulation in a previous generation, saprophytic or parasitic, inasmuch as spores are, of course, essentially necessary for the primary infection. What applies to infective invasion by fungi in relation to plant-tissue might with equally good reason, perhaps, be applicable to fungal invasion with regard to the production and spread of disease in animal tissue with special reference to mycetoma. Hence I put forward the suggestion comprised in the query. Can it be that the parasitism displayed by either variety of the disease originates in the *black* kind by infection from hibernating mycelium, and in the *white* by infection from spores, both these morphological elements belonging, of course, to one and the same species of fungus vegetating outside the human host either as a parasite or as a saprophyte?

If you bear with me awhile, I shall go a step or two further to show that this theory seems to adapt itself more or less to facts as observed in connection with (*a*) the main and most important clinical features of mycetoma, (*b*) the microscopical preparations of the diseased tissues, and (*c*) the artificial culture of the micro-organism, together with the results of inoculation with the culture-product.

(*a*) From a clinical stand-point based on this theory one is in a fair position to appreciate the significance of the following phenomena manifested by the disease, namely, the exclusion from the sinuses, throughout the whole course of the disease running perhaps over many years together, of either black or white particles but never of both simultaneously or consecutively; next, the recrudescence of the two specialized types each in its identical individual characters when the lesion has not been completely extirpated by surgical operation; and, as observed on section of the tumour in various directions, the non-occurrence of black and white particles together in one and the same specimen, that is to say, cases of a kind where the two sorts of particles are found mixed up together *indiscriminately*. Of course, in rare instances, it is possible that by dual infection a dual manifestation may follow when I should expect the lesion in each of the two types of the disease would, at the most, be in close proximity to each other.

Further, it is a fact well-known to mycologists that hibernating mycelium is not only a prolific but also a rapid source of propagation of disease in plants, and based on this assumption the following clinical points in connection with mycetoma also admit of interpretation. For instance, as suggestive of the rapid growth expansion of the hyphae in the black variety, it is observed that, as compared with the white, black tumeurs are generally for co-eval periods of development, of quick growth and of large size, the cysts in them are bigger and more capacious, and the fungal contents of the cysts of much looser texture than in the white.

Then again, as in the case of inspection of plant tissue through the agency of hibernating mycelium, laceration of the external textures whether of the root, bark, or rind of fruit, etc., plays an important part in the spread of disease in plants, so also, in the case of the human disease under consideration, it is clinically noted that the black variety identifies itself very closely and frequently (nearly 75 per cent. as compared with the white) with wounds and injuries.

Clinical history, in addition, indicates that the white variety even within endemic areas, *e.g.*, in Madura district and in Sind, occurs, much less frequently than the black, the actual relative number, according to statistics for Sind, being 16 of the former against 284 of the latter in a total of 300 cases. On the supposition that the white variety originates from spores, the significance of these figures, viewed side by side with the circumstance that the exciting cause of this type is seldom attributed to accidental injuries, becomes apparent. It suggests, on hypothetic grounds, that infection by spores is rare and that this mode of infection does not necessarily need the intervention of wounds for the entrance of the organism into the human body. In the case of the black variety, on the other hand, with its louder history of association with wounds and injuries, a different mode of infection is implied, namely, that by resting mycelium, and the presumption is that the mycelium, vegetating at first outside the human body, probably as a saprophyte, on such foreign substances as thorns, prickles, stumps of plants and trees, or possibly the vegetable humus of swampy soils, subsequently gains entrance into the human body through the medium of wounds and spreads luxuriantly in its new host finding here the pabulum fit for its growth and development.

(*b*) As regards the microscopical preparations of diseased tissues, the evidence in support of the theory is borne in part by observed facts and in part by conjecture. The facts that both varieties, melanoid and ochroid, display practically the same morbid features and the same pathological expression, that both are characterized by the same sort of fatty metamorphosis as already described, and both are attended with a peculiar form of pigmentary degeneration, appear to indicate that the fungal forms responsible for these changes are in some manner closely connected with each other. If the role played by these forms be accepted as being that in connection with the processes of nutrition, the existence of a biological relation between the two organisms may be inferred.

But what do we find when we come to note the characters of the fungal elements themselves? In the black variety the microscope shows naught else but an interlacing system of mycelial filaments closely resem-

bling one of the fungi of the uncertain genus Hyphomycete, a class of vegetable parasite or saprophyte known to mycologists as "fungi imperfecti." It is a fact worthy of note that some of these imperfect forms of fungi have already in connection with their mode of vegetation been shown to be merely phases of growth in the life-cycle of certain higher forms of fungi, although it must be admitted that, so far as at present investigated, several autonomous species are, no doubt, to be found. As regards the white variety, the containing micro-organism is microscopically demonstrated as being quite different in character from that in the black: it is shown to be a specific form of fungus bearing the general characters of the species Streptothrix. The question arises then, can it be that the former, the lower type of fungus, is in some way morphologically connected with the latter, the higher type, or, in other words, is one organically continuous with the other through an intervening stage of saprophytic existence? In this connection the fact that both varieties occur endemically together is very suggestive.

(c) Looking to culture experiments for evidence in this direction, so far at least as experiments conducted up to date is concerned, we find that while in the case of the white variety the organism is more or less readily cultivable, and has been successfully cultivated by many experimentalists, the black variety has offered considerable resistance to artificial cultivation, and, so far as I know, has hitherto been successfully cultivated in one instance only, namely, by Wright of Philadelphia. Why is this so? We must again seek the aid of the mycologist for an explanation. Masse says, to quote his own words, that the more modern method of infection by means of hibernating mycelium is quite as effectual and much more economical than the most primitive and most general infection by means of spores, and he adds, that, when the balance between fungus and host-plant is perfect, infection by means of hibernating mycelium is rendered so certain that the production of spores is completely arrested. This latter point, to my understanding, affords a plausible explanation of the peculiar behaviour displayed by the two organisms in the attempt to cultivate them artificially, and it likewise suggests that the organism in the black type of mycetoma is probably of the resting or hibernating character.

Actual proof of the organic continuity above indicated can, of course, only be obtained from culture experiments and inoculation, together with a further study of the fungus (or fungi) of mycetoma from its biological and morphological aspects, and this matter opens up avenues of far-reaching interest to the bacteriologist as well as to the mycologist relative to the pathogenic effects of fungi as much on the animal as on the vegetable world.

DISCUSSION.

Dr. Thos. Campbell said:—I should like to ask if there is any definite information with reference to the occurrence and distribution of the *red* variety of Mycetoma in India. In one District (Cuddapah, Madras Presidency) the white variety is common and the black variety is also met with. During 17 years, I have seen about 200 cases of Mycetoma. During the past 3 years I have seen 3 cases of the red variety. One of these specimens I have sent to the Liverpool Tropical School Museum. The granules are of a bright carmine red colour, and, when examined under the microscope, present a most brilliant carmine appearance.

Section IV.

SYSTEMS OF DISPOSAL OF SEWAGE IN INDIA, WATER SUPPLIES, DISINFECTION AND NAVAL AND MARINE HYGIENE (INCLUDING QUARANTINE).

Sectional President.

LIEUT.-COLONEL C. J. BAMBER, I.M.S., Officiating Sanitary Commissioner with the Government of India.

Vice-Presidents.

LIEUT.-COLONEL J. CRIMMIN, V.C., C.I.E., I.M.S., Health Officer, Port of Bombay.

FLEET-SURGEON F. H. A. CLAYTON, M.D., M.R.C.P., Senior Royal Naval Medical Officer, E. I. Station.

LIEUT.-COLONEL T. E. DYSON, M.B., I.M.S., Sanitary Commissioner for the Government of Bombay.

LIEUT.-COLONEL SEMPLE, R.A.M.C.

DR. J. A. TURNER, M.B., D.P.H. (Executive Health Officer, Bombay Municipality).

Secretary and Sectional Editor. — DR SORAB K. NARIMAN, M.D., B.SC, D.P.H., L.R.C.P., M R C.S.

Assistant Secretary. — DR. P. A. DALAL.

Presidential Address by Lieut.-Colonel J. CRIMMIN, V.C., C.I.E., D.P.H., I.M.S., Vice-President of the Section.

Owing to the unavoidable absence of the President, the pleasant duties of welcoming you here and of opening this Section of the Bombay Medical Congress have devolved on me.

In this Section papers on the Disposal of Sewage in India, Water Supplies, Disinfection and Naval and Marine Hygiene including Quarantine will be dealth with.

As these are all matters involving heavy, sometimes

General View of Stands in the Main Exhibition Building
with Nestle's Milk Kiosk in front.

The Bombay Improvement Trust Exhibition Hall.

extremely heavy, expenditure, it is important for those concerned with the protection of the public purse, to feel assured that it is being undertaken with wisdom. In remote lands like these, where the best advice is not always accessible on the spot, public works of much sanitary utility are likely to be constantly held up through a certain natural suspiciousness that, after all, the proposals submitted might be only the particularist views of an individual official which might prove to be at variance with the equally particularist views of his successor. There is no man so able that the limited field he cultivated may not be benefited by many sidelights let in upon it from the garnered stores of other expert intelligences. When proposals have been winnowed by discussion, and have the approval of the most varied experience from East and West, when it is seen that they are not an exhibition of hobby riding, or the expression of a single narrow groove, when, in fact, finality of plan has been made acceptable by its reasonableness, then the great strategy of tergiversation and pigeon-holing—not unknown in public officess—will be deprived of its last redan. Financial authorities, having the goodwill, can then move with a safe conscience and a serener assurance that the outlay in one form or another is bound to prove remunerative for the public good. It is for this reason among others that the experience of many minds from many lands is so valuable at these international assemblies. And, though efficiency is the first objects sought for in all hygienic enterprises, the practical man will always bear in mind that the public back, however broad, is certain to jib at new cyclopean burdens and that, to get work done, the sanitarian will be just as mindful as the Finance Minister how economy is just as necessary a watchword as any other.

As there are many important papers to be read and discussed, and, as the time at our disposal is somewhat limited, I do not propose to detain you any longer and therefore declare the Section of the Congress open.

WATER SUPPLIES, METHODS OF ENSURING PURITY, &c., &c.

By JOHN C. THRESH, M.D., D.SC.,

Medical Officer of Health, Essex County, Lecturer on Public Health, London Hospital, London.

The importance of a pure water supply having been so frequently discussed it might be assumed that it might be now fully recognised. This, however, is certainly not the case. The general public still remain ignorant and apathetic, and even sanatarians have not as yet fully realized its necessity.

It has hitherto been assumed that the introduction of a pure water supply prevented an undue prevalence of Typhoid Fever and Cholera, and thus reduced the zymotic death-rate. No further effect has until recently been recognised, but there is reason to believe that a supply of pure water diminishes the death-rate from other diseases and has a marked effect upon the general mortality. Wherever a pure water supply is substituted for an impure one the death-rate declines. An excellent example is afforded by two neighbouring towns of similar size and with a similar population, in one of which a system of careful filtration of the water was introduced, whilst unfiltered water continued to be used in the other.

The figures given are quoted from Whipple's "Typhoid Fever."

Albany.

	Death-rate per 100,000.		Per cent. reduction of death-rate.
	1894-98. Before filtration of water.	1900-04. After filtration.	
Typhoid fever ...	104	26	75
Diarrhœal disease ...	125	53	57
Children under 5 ..	606	309	49
Deaths from all causes	2,254	1,868	17

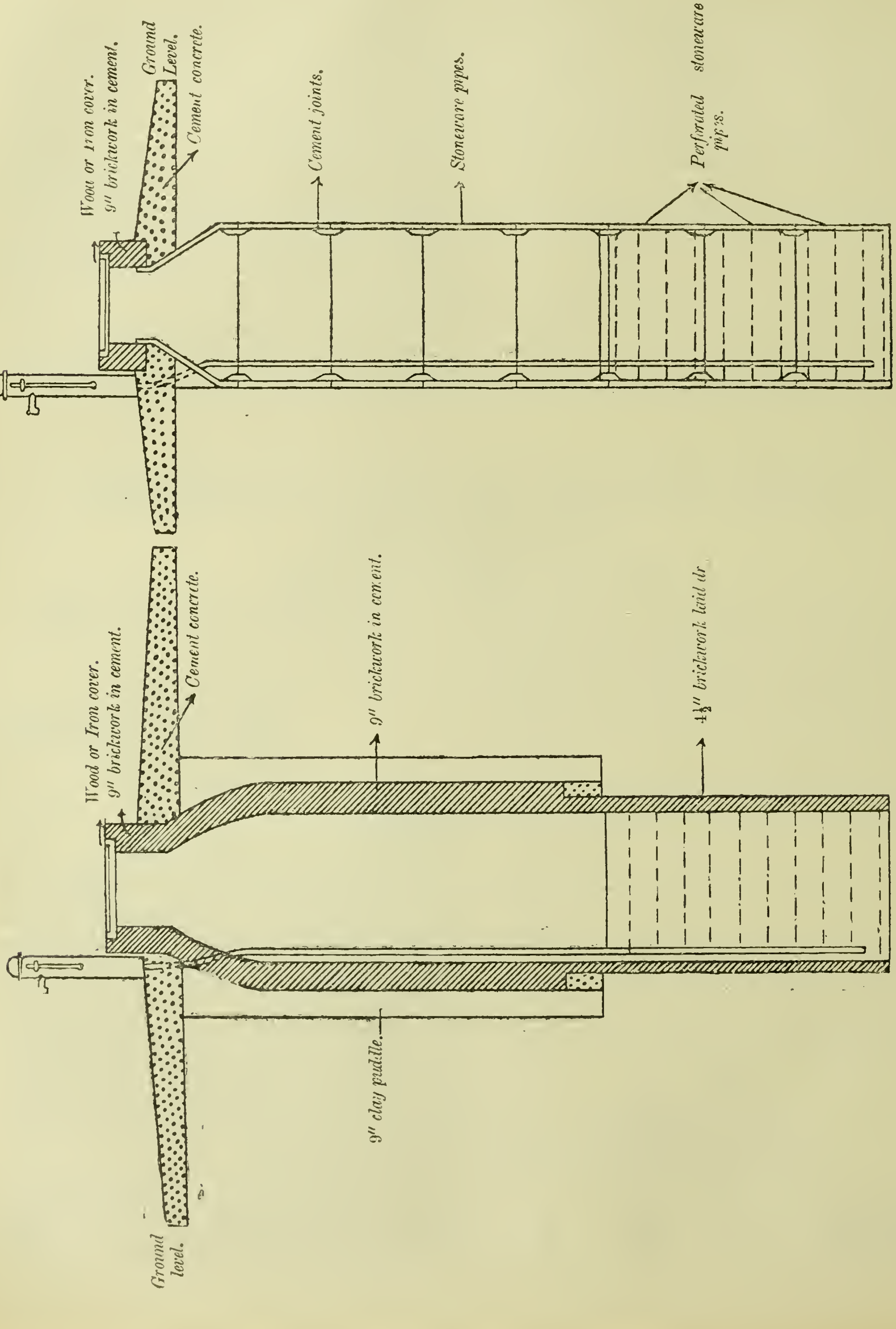
Troy.

	Death-rate per 100,000.		Per cent. reduction of death-rate.
	1894-98. Before filtration of water.	1900-04. After filtration.	
Typhoid fever	47	57	......
Diarrhœal disease ...	116	102	12
Children under 5 ...	531	435	18
Deaths from all causes ...	2,157	2,028	6

It is undoubtedly better to prevent the pollution of a water than to attempt to remove the polluting matter after it has gained access, and only when it is impossible to prevent pollution it is justifiable to depend upon any system of purification. In a hot climate like that of the Bombay Presidency, where the rainfall is very heavy at certain seasons and where months of drought occur, there will be a greater difficulty in preventing pollution than in areas where the rainfall is more equally distributed, but much may be done by efficient sanitary administration.

Where water is derived from rivers and streams prevention is often impossible, but every effort should be made to prevent the discharge of sewage into the streams or their tributary ditches.

Where moorland water is impounded the catchment area must be carefully selected and efficiently supervised. Lakes may become seriously polluted by towns and villages on their banks, by boats plying on the surface, etc., but frequently some portion is found which is much


Wood or Iron cover.
9" brickwork in cement.
Ground Level.
Cement concrete.
Cement joints.
Stoneware pipes.
Perforated stoneware pipes.
Wood or Iron cover.
9" brickwork in cement.
Cement concrete.
9" brickwork in cement.
4½" brickwork laid dr
9" clay puddle.
Ground level.

less liable to pollution than others. As a rule, however, water from any of the above sources requires to be purified before being safe for use for drinking purposes.

In constructing wells it is possible to take precautions which should ensure the purity of the water, unless the site of the well is on sewage sodden ground. The well should be constructed according to the subjoined diagram and the ground around for several feet should be rendered impervious. The greater the amount of water drawn the greater the area which should be paved or concreted and all waste water should drain off this area. With a well so constructed and protected no water can enter which has not filtered through many feet of soil, whereby most of the organic matter is oxidised and most of the bacteria removed. In many districts in England no new house deriving its supply from a shallow well is granted a certificate for occupation unless the well is constructed in the way described.

Of course these precautions are unnecessary in the case of deep tube wells, but if the upper portion of such wells are excavated the same precautions are necessary as in the case of a shallow well. Time will not permit of my dealing with the question of water purification, but I may add that only two methods are known which will secure safety. The first consists in slow sand filtration to remove over 99 per cent. of the bacteria and the other treatment with chlorine to effect practical sterilization. For this latter purpose the water must contain very little suspended matter and very little readily oxidizable organic matter.

When such is the case 1 part of chlorine contained in 3 parts of calcium hypochlorite (chloride of lime) will affect practical sterilization in from $\frac{1}{4}$ to 1 hour and the excess of chlorine may be removed by adding a little sodium bisulphite. In this way 1,000,000 gallons of water may be sterilized for a few shillings.

When a water is turbid merely from the presence of mineral or vegetable matter and is free from sewage pollution some form of mechanical filtration will suffice for clarification, but rapid filters are of little use for removing bacteria unless some form of chemical treatment is also employed.

A NOTE ON THE STORAGE OF DRINKING WATER ON BOARD OF SHIPS.

By Lieut.-Colonel J. CRIMMIN, v.c., c.i.e., d.p.h., i.m.s.

The storage of drinking water on board of ship in suitable tanks protected against contamination is very important. If the drinking water on board becomes contaminated from any cause a fresh supply cannot, as a rule, be obtained until the vessel arrives at the next port of call, except in the case of vessels which are provided with a condensing apparatus. Condensed water on board of ship is not always free from deleterious matter and is in all cases insipid to the taste owing to its non-aeration. Therefore the drinking water taken on board should be scrupulously guarded against fouling.

Some time ago a special examination of the water tanks on board of the ships then lying in the Port of Bombay was made. It was found that all such tanks were placed in the bottom of the ships right under the cargo and over, or close to, the bilges. Drinking water is pumped into the storage tanks from a water boat alongside of the ship, and in order that the water may be pumped into the empty tanks they are provided with an air pipe to enable the air in the empty tank to escape and the water to take its place.

In 26 of the 215 ocean-going ships examined we found that the air pipe from the top of the water tank was bent into the shape of an inverted U and opened over or into the bilge. This enabled the air to escape from the tank while the water was being pumped in, and it also allowed any overflow of water to find its way into the bilge without damaging the cargo.

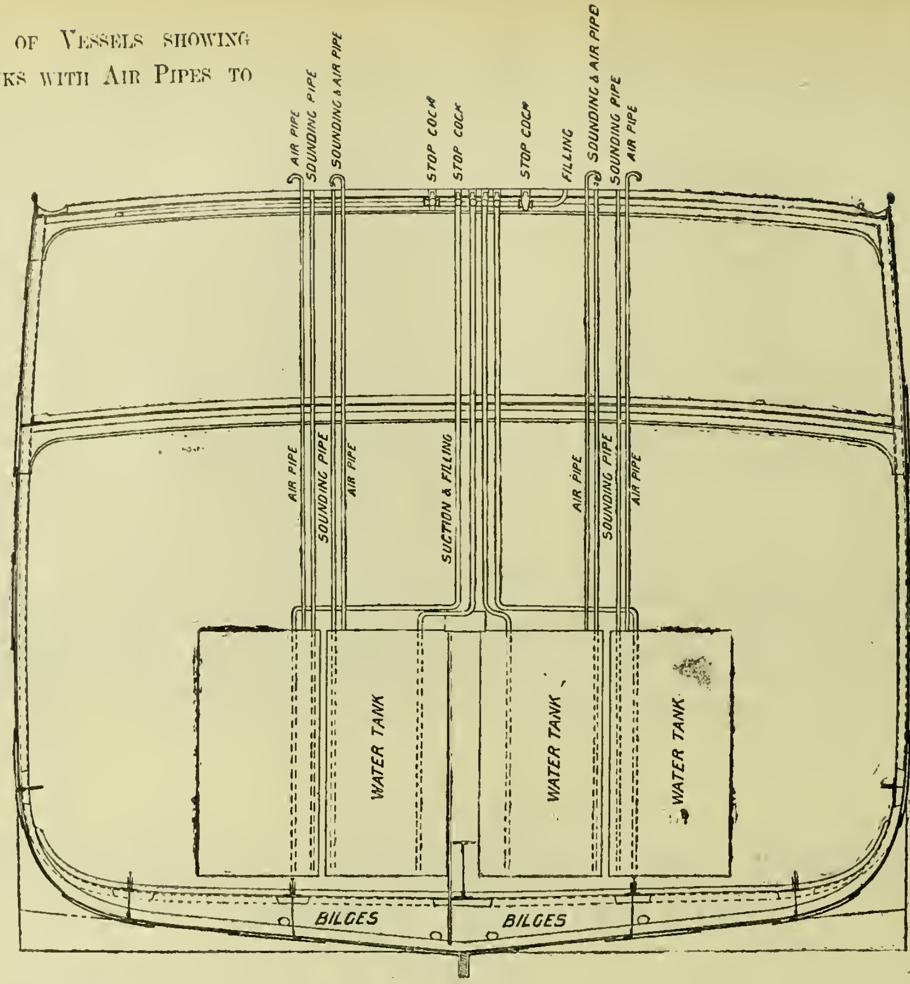
The bilges almost always contain stinking water and foul and poisonous gases such as Sulphides of Ammonium and Hydrogen, and the effluvia from the various kinds of animal and vegetable cargo on board. It can easily be understood that the air pipes when arranged as described give an opportunity to the mephetic gases from the bilges and hold, cockroaches, rats and other small animals to enter the storage tanks as the water in them is being pumped out for consumption. Water under ordinary conditions can absorb about 3 per cent. of gases and I have no doubt that some outbreaks of illness of a gastro-intestinal nature on board ship are due to the consumption of contaminated water.

Drinking water on board of ship should be stored in tanks made of galvanised iron, or in tanks of iron coated on the inside with a vitreous glaze and so constructed that no gases from the bilges or holds can find their way into them. The air or overflow pipe from the tanks should be brought up on deck and so placed and protected that no filth or foul air can gain access to the drinking water tanks. All tanks should be carefully cleaned out periodically.

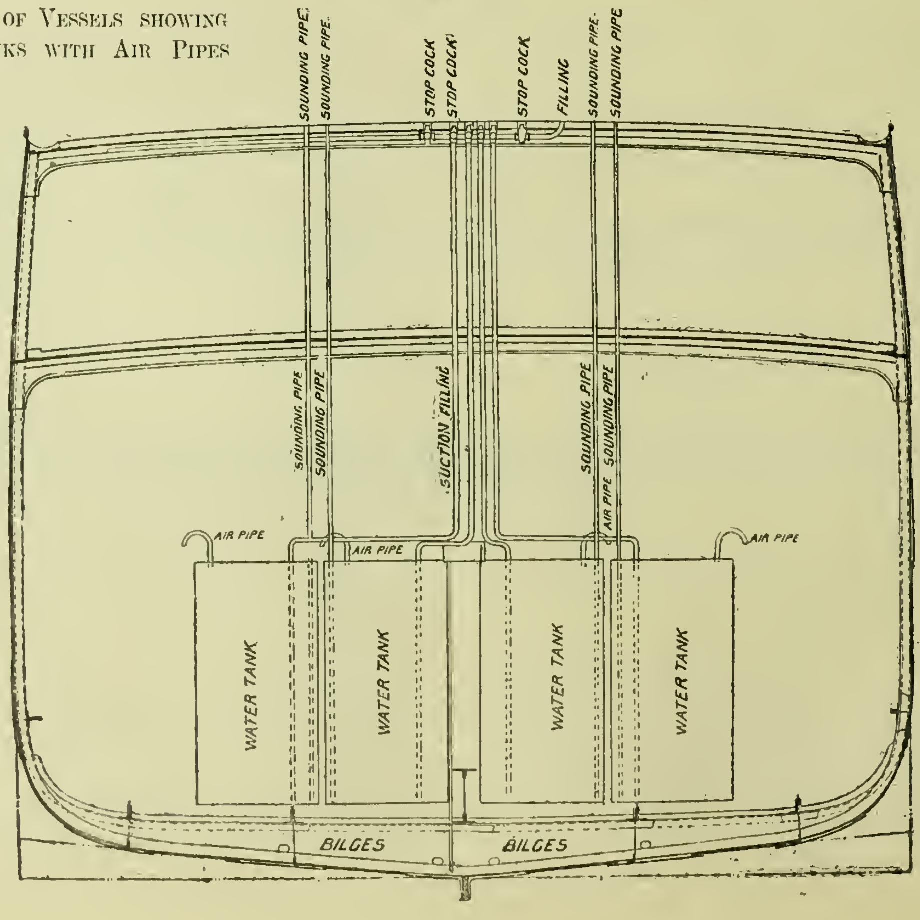
Steps have been taken to remedy the defect mentioned but nothing short of an International agreement will be sufficient to enable Port Health Officers and others to deal with the ships of all nations.

The following two plans show the position of water tanks with air-pipes on ocean-going ships.

No. 1.—Section of Vessels showing Fresh Water Tanks with Air Pipes to Deck.



No. 2.—Section of Vessels showing Fresh Water Tanks with Air Pipes into Hold.



PURITY OF WATER AND MEASURES NECESSARY FOR THE PURITY OF WATER.

By Dr. K. E. DADACHANJI.

A question of great importance to the community is the character of its water-supply and of equal importance to the individual is the purity of the water that is used in his household whether it comes from a City main or an isolated well in the country. That this was not always so considered hardly requires mention, for it is not a great many years since disease was considered a direct visitation of Providence. The theory that water is one of the most dangerous carriers of infection of cholera and of typhoid fever may be said to date from 1872, and to have been the result of the careful investigation of the typhoid fever epidemic in that year in Lausen, Switzerland.

To-day we recognise as one of the best established theories of Sanitary Science that both cholera and typhoid are water-borne diseases and that the primary cause of the large death-rate from typhoid fever is due to the use of polluted waters.

Hence the question of the supply of water suitable for domestic purposes is becoming more and more a subject of supreme importance.

Chemically no water in its natural state is pure. Chemically pure water is one consisting only of two parts by weight of hydrogen and sixteen parts by weight of oxygen. Water, such as a Chemist would deem pure, would be unpalatable, and not at all suitable for dietetic purposes.

Hard and Soft Water.

All water-supplies are, as it has already been said, due directly or indirectly to rain, and when it passes through the atmosphere the rain takes up certain impurities according to the surrounding circumstances ; when it reaches the ground it takes up more impurities. Again the quality of water is more or less governed by the course it takes. If it passes over lime-stone, it dissolves some of the lime and becomes what is known as "hard water." When it passes through peaty ground it takes some of the peat, thus making it more or less turbid and acid, this would generally be what is known as "soft water" and is more suitable for manufacturing purposes than hard water. Hence we get in water what is termed "matter in solution" and "matter in suspension."

Characters of exceptionally Pure Water.

Exceptionally pure water, if seen in thin layers, appears practically colourless, but, if seen through a tube, it has a blue appearance. The blue colour denotes purity. We find such colour in waters of the Himalaya as Darjeeling, &c. One very good example of this colour in water is often quoted and that is that derived from the springs and galleries driven in the lime-stone in and around Spouth in the valley of Bocq, in Belgium, from which Brussels derives its supply. There the water appears blue with a slight tinge of green in it and is of such excellent quality that it does not require filtering.

It is true that many normal waters, on account of the large amount of vegetable matter they contain, are unfit for household use, although they may be sanitarily safe waters in the sense of not being vehicles of the germs of disease.

Hence the sanitary value of a water analysis depends not on determining the amount of organic matter which a water contains, but on the amount of information it can give in answer to the question "Is a given water normal or a polluted water?" or stated in other words, "How far can analysis determine whether or not the organic matter in a water is of vegetable or animal origin?"

In order to answer this question it is necessary to divide natural waters into three classes :—(*a*) surface ; (*b*) subsoil or ground ; and (*c*) artesian waters. It is often urged that there is no value in a sanitary analysis of a surface water and that an inspection of the water-sheds and gathering or drainage areas may give all often much more information than can be obtained from the analysis of the water. If sewage is seen to be entering a well, river, tank, pond or lake, an analysis is unnecessary to show that it is polluted. If the water-shed is uninhabited the water cannot be polluted.

Survey of Gathering Ground Necessary.

Even with a careful and proper analysis there is no question about the value of a survey of the draining areas and gathering grounds. This sort of survey not only aids in drawing the proper deductions from the data of an analysis, but that often it is unnecessary for a correct explanation of the data. Hence it is highly necessary to attend to the sources of water-supply time after time, because there is great danger in using water for drinking purposes from a polluted source, even though after filtration it is clarified.

Sir Alex. Binnie on Polluted Sources.

No less an authority than Sir Alexander Binnie informs us that part of the existing supply of London is from a polluted source. Between the town of Hertford and the intake of London supply he tells us, about two million gallons of crude sewage per day are discharged into the river. This is no doubt a terrible amount of pollution. It is well known that London water-supply is distributed after careful filtration and analysis. Still Sir Alexander Binnie holds this view of its quality because one of its sources is grossly polluted. Sir Alexander Binnie in his lecture about two years ago graphically described the effect of such

pollutions. He told his hearers that it might not be in his life-time but as sure as they were round that board, there would come a time when, as in times past, there would arise among the teaming millions of London an epidemic such as that visited Hamburg a few years ago, owing to the consumption of the polluted waters of the Scheldt. He said that chemists might tell him that the water was pure, but, as Sir George Buchanan informed the Commission, it was a well-known fact that population might go on drinking water from a polluted source for a long time, and that ultimately, from causes which they could not detect, the water took upon itself certain qualities, and people died by the thousand.

Sir Alexander is no unnecessary alarmist and as a sound sanitarian he believes in a water-supply from a pure and uncontaminated source as of the very essence of Municipal life.

Notwithstanding this warning, there are many cases where, unless large interests are involved, a careful and complete survey of the sources is practically impossible, more especially in India, the sources of pollution in the case of large rivers being complex, and on account of the expense. Thus one has to place the chief reliance on filtration and the result of the sanitary analysis. Hence it appears that, very early in the study of polluted waters, attempts were made to devise methods of detecting certain definite organic compounds which were known to be formed by the decomposition of the nitrogenous products contained in sewage, but without success; because the decomposition of the nitrogenous products contained in sewage takes place so rapidly that the isolation of any particular compound like crystin, or any group of compounds like the amido-group, can only be looked for when the pollution is very recent and in very large amounts.

Though it is apparently impossible to isolate from a water any particular nitrogenous organic compound known to occur in sewage, the late Sir Edward Frankland succeeded in determining the amount of nitrogen and the amount of carbon contained in these compounds in a water, and in other words he distinguished whether the organic matter in a water was of animal or vegetable origin.

I need not enter into very elaborate chemical experiments performed by Sir Edward in this respect. But I would content myself by quoting some of his important conclusions.

Sir Edward Frankland's Conclusions.

Sir Edward concluded that, if the ratio of nitrogen and carbon was as low as 1 to 3, the organic matter was of animal origin; if as high as 1 to 8 it was chiefly, if not exclusively, of vegetable origin, and that if the ratio was between these two proportions the analyst must be guided in his opinion by the amount of inorganic nitrogen the water contained.

It is very difficult to carry out these experiments in small and poorly equipped laboratories.

Water Purification.

This brings me to the subject of water purification. In a limited number of cases the natural supply from a lake or reservoir is sufficiently pure for direct consumption, but in most instances the application of mechanical or chemical science and a combination of both is essential.

Sand Filtration.

Mechanical filtration through beds of sand is one of the oldest means of effecting the necessary purification, and in certain cases, under suitable conditions and care, affords excellent results. In the case of sand filtration, sand used may be obtained from the sea-shore, from river-beds or from sand banks, and on this depends the efficiency of the filter. Generally speaking the finer the sand the better the bacterial result, because the passages between the grains of sand through which the water passes remains extremely small, and as the result the coarser matters in the water are retained on the surface of the sand, where they quickly form a layer of sediment which itself becomes a filter, much finer than the sand alone. This layer is capable of holding back even bacteria of the passing water.

It is said that this layer is formed by the gelatinous matter due to bacteria which fills the interstices of the sand. Prof. E. Ray Lankester says that, owing to this gelatinous layer, a sort of osmotic process is going on which renders the filtration very perfect. This gelatinous layer is known by various names as "jelly-like layer," "sling layer, dialytic and colloidal layer" or "film," "biological layer," "purifying layer," &c.

Prof. Lankester thinks that there is another chemical process going on in this layer, due to the accumulation of bacteria in which one is destroying the other.

As regards the efficient filtration much depends upon the formation and integrity of this jelly-like layer or membrane.

It should be remembered that the micro-organisms in the earlier stages of their attachment are feebly adhered to the grains of sand and slight sudden increase in the speed of filtration or the application of excessive and irregular pressures would not only detach them but even scour them away into the filtered water channel.

Hence, it is necessary to reject the water first passed through a sand filter until the "purifying layer" has properly formed. Care must be taken to preserve the surface film absolutely intact and the filtered water must be constantly examined, and it must be possible to disconnect at once any filter-bed passing water which is not up to a requisite standard of efficiency.

Now that public opinion is making its influence felt and the time has come when no public supply will be considered satisfactory at all times, it is perfectly clear and pure and attains a certain amount of bacterial purity. In these days haphazard work can no longer be tolerated, the whole process must be conducted in a scientific manner and under the control of specially qualified men.

Cleaning of the Filters.

So far as the efficiency of filtration is concerned, the seldomer filters are cleaned the better. Those Companies and Corporations which clear their filters most frequently deliver by no means the best water from a bacteriological point of view. The greater the thickness of sand the better the results are.

But as the suspended matters accumulate upon the surface of the filters the rate of filtration falls off until finally the surface must be skimmed and filters washed and resanded. In order to do this, it is necessary to see that persons employed for the purpose are not typhoid carriers.

Rate of Filtration and when a Filter should be shut-off for Cleaning.

Every water has its own special rate of filtration, and this must be determined by local experiments, and the rate thus arrived at may also vary. In Bombay, in the case of Tulsi water, this rate of filtration was fixed at 627 gallons per square yard per day by the late Dr. Cayley after conducting some experiments. Mr. Santo-Crimp considered for Bombay a limit of about 500 gallons per square yard per day as sufficient. Prof. Koch says that there should be no rate exceeding 450 gallons per square yard per day. Piefke recommended the rate of 2·57 million gallons per acre daily.

Each filter should be provided with a contrivance by means of which the motion of the water in the filter may be restricted to a certain rate, and by means of which it may also be ascertained at any moment whether this rate is observed or not.

A perfect filter is to arrest organic matter and bacteria. After the gelatinous membrane is formed gradually the pores of the filtering medium becomes clogged up. "Filters," says Mr. Dibdin, "act only well when they deal with inert matter but when the particle to be arrested is alive and swimming freely, the case is altered." The bacteria drawn into the medium by the flow of the water find themselves swimming about in what are to them "comparatively large caverns." With coarse materials they quickly get right through and emerge at the outlet of the filter.

When the membrane is well formed no bacteria can pass directly through, turn and twist as it may.

What happens then ? It settles on the outside of the material and proceeds to grow. Gradually it spreads itself throwing out shoot after shoot. Some of these in time force their way through the minute pores of the filter and then there might just as well perhaps better be no filter at all. Hence, there comes a time when this slime must be removed.

Cleaning the Slimy Layers.

Mr. M. W. Hervey, M.I.C.E., says that a filter should be shut off for cleaning when the rate falls two inches per hour. If this is not done then there will be loss in head, and filtered water would be just as if not filtered at all.

In connection with the filters there are two important factors which are of the greatest importance :—

(*a*) That the rate of filtration must be as slow and under as uniform a pressure as possible.

(*b*) Storage capacity of unfiltered water greatly reduces the task imposed on filters.

Storage of Unfiltered Water.

The first of these two factors I have already dealt with. As regards the second factor, it used to be thought that storage of unfiltered water was highly objectionable. Lord Balfour's Commission raised this objection in 1893 and prohibited the storage of the unfiltered water. Only a few years later, this objection disappeared. An eminent chemist and bacteriologist in 1896 stated that the bacterial improvement of river water by storage for even a few days is beyond all expectations. After this Lord Llandaff's Commission on London water-supply in 1899 stated that "no restrictions need be placed on taking flood water." Dr. Houston's interesting experiments clearly demonstrated how it was possible to bring about the destruction of all harmful bacilli by storage. He found that one week's storage sufficed to destroy 99 p. c. of the bacilli, and it had been established that storage was as strong a line of defence in getting rid of noxious elements in water as filtration. When storage is followed by filtration there is absolutely no danger to the public in the consumption of river water.

Washing of the Sand.

The English, Indian and most of the German sands are washed, even when entirely new, before being used to remove fine particles.

Sand free from Lime.

It is also important that filter sands should be free from lime, in order to avoid hardness of water from this cause. Always sand free from lime is to be preferred. The presence of lime can easily be detected by moistening it with hydrochloric acid. The evolution of gas shows the presence of lime. Both the quality of the effluent obtained by filtration and the cost of filtration depend upon the size of the sand grains. With the fine sand as stated above, the gelatinous layer forms more quickly and the removal of bacteria is more complete, but, on the other hand, the filter clogs quicker and the dirty sand is more difficult to wash unless an apparatus is provided for the purpose, so that the expense is increased.

For comparatively clear lake or reservoir waters a finer variety of the sand could probably be used than would be the case with a turbid river water. In Bombay usually Cutch sand is used. In Cawnpore, once an outbreak of cholera was traced to the use of sand for filtering purposes having been contaminated by the cholera dejecta.

Sand must be of the same quality throughout.

Great pains should be taken to have the sand of the same quality throughout, especially in the same filter, as any variations in the grain sizes would lead to important

variations in the velocity of filtrations; the coarser sand passing more than their share of water and with reduced efficiency.

Size of Filters.

The total area of filters required in any case is calculated from the quantity of water required, the rate of filtration, and an allowance for filters out of use while being cleansed.

It is also frequently urged that with large filters it is difficult or impossible to get an even rate of filtration over the entire area owing to the frictional resistance of the under drains for the more distant parts of the filter. The cost per acre is decreased with large beds on account of there being less wall or embankment required but thereby the convenience of operation may suffer.

Form of Filters.

The form and construction of the filter beds depend upon local conditions and requirements.

But in the construction of the filter-beds one thing should be borne in mind and that is that the bottom of the filter beds should be made water-tight either by a thin layer of concrete or by a pavement upon a puddle layer.

Malabar Hill and Bhandarwada Reservoirs of Bombay.

In the case of Malabar Hill and Bhandarwada Reservoirs of Bombay, the bottoms of the filter-beds not being water-tight caused great leakage. The water in the filters is higher than the ground water, or under reverse conditions, the ground water comes in and mixes with the filtered water and thus filtered water is seriously damaged by the admixture; and with very bad conditions water may pass from one filter to another with the differences in pressures always existing in the neighbouring filters with most unsatisfactory results. Such is the case in Bhandarwada reservoir filters.

Open versus Covered Filters.

Filters are generally built open without protection from the weather. It appears that in Berlin an epidemic of typhoid fever occurred and on investigation it was found that it was confined to that part of the City supplied from Stralau Works where there were open filters, those wards supplied from the covered Tegas filters remaining free from fever; since then open filters have been abandoned in Berlin.

At Zurich, where open and covered filters were long used side by side, the covered filters were much more satisfactory and the old open filters have recently been vaulted over.

The cost of building covered filters is said to average fully one half more than open filters.

Advantages.

Among the incidental advantages of covered filters there is this advantage that with the comparative darkness there is no tendency to algal growths on the filters in summer and the frequency of scraping is therefore somewhat reduced.

It has been supposed that covered filters kept the water cool in summer and warm in winter.

Except in severe winter weather at Berlin bacterially the open filters were more efficient. It was at one time supposed that this was caused by the sterilizing action of the sun-light upon the water in the open filters. This supposition was not confirmed elsewhere.

In Bombay, Malabar Hill Reservoir filters are covered owing to their proximity to the Parsi Towers of Silence but Bhandarwada filters are open.

"Intensive" Working of Filters.

More recently "intensive" working has largely come to the front and the high mechanical efficiency and output of the many modern water purification and filtration plants mark a great advance on former practice.

In both the slower sand filtration and more rapid mechanical filter methods, however, chemical science has come to the aid of the engineer and not only facilitated his work largely but rendered possible the achievement of results hitherto unattainable.

The "life" of a sand filter-bed and its efficiency are, it is now generally recognised, greatly increased by the preliminary elimination of the major part of the suspended impurities contained in the water under treatment.

Alum.

To effect this removal the well-known properties of hydrated alumina precipitated in situ are utilised.

In India for centuries it has been in common use for the clarification of water and is capable in itself in effecting such efficient purification that subsequent filtration is at times almost a work of supererogation.

Mode of Action.

Properly applied, alum, when decomposed by the bicarbonate of lime contained in nearly all waters, precipitating insoluble hydrate of alumina in a gelatinous form which enmeshes, entangles and carries down bacterial and suspended matter alike, leaving the purified water brilliantly clear. It not only removes germ-life and other impurities but the precipitated alumina exerts its mordant or colour-precipitant action and thus removes the objectionable yellow or brown colouration of peaty or surface waters which so frequently detracts from the appearance of otherwise suitable supplies.

Expense.—Alumino-ferric Compound.

But alum is expensive and leaves a little potash or ammonia sulphate in the treated water, hence it is necessary to use alumino-ferric compound of alum. It is a very cheap and efficient form of sulphate of alumina, containing nearly 50 per cent. of that substance and a small proportion of iron-sulphate. Strength for strength it is about thrice as cheap as alum. The only change it effects is that it changes the temporary hardness of water into a permanent one. The quantity required is $1\frac{1}{2}$ grains per gallon and the results both from the appearance and bacteriological aspect are excellent.

As I said above alum was used centuries ago in India, but in Europe only recently it has come to be regarded

as an essential coagulant in the majority of rapid filtration plants dealing with water containing difficultly sedimented matter.

As Nile water offers considerable difficulty on account of the presence of very fine particles of clay, it is necessary to coagulate the suspended matter in a sedimentation tank. Recent reports on the use of alumina for the purification of the Alexandra water-supply are very satisfactory.

It is on this principle that what are known as Jewel Filters have been constructed by Messrs. Morison Jewel Filter Company of New York. It is apprehended in some quarters that there will be some injurious effect on the public health by drinking water constantly charged with chemicals, but it may be mentioned that Officers of Health in America, in some 40 to 50 towns using alum-treated water, attribute no ill-effects to its use and the water has had no injurious action on boilers.

Purification by Copper Sulphate.

Dr. G. T. Moore, Director of the United States Government Laboratory of Plant Phynology, has discovered a method of destroying virulent cholera and typhoid bacilli in water by means of copper sulphate. Dr. Rideal read a paper at the Glasgow Congress of the Sanitary Institute in 1904 on the same subject. Perry and Adams, in the Fourth Report of the Rivers Pollution Connecticut, have found that 1 in 200,000 is not injurious to minnows and gold-fish, and in general, animal life seems to be less susceptible to copper than plant life. It also prevents the growth of algæ.

Some such use of copper must have been known to the ancient Hindoos, as copper vessels were used by them for storing water. Even in England there are some who agree with the Continental observers as to the harmlessness of quantities of copper for adults, even up to one grain per day. It is said that *chloride* of copper is more efficient than the sulphate.

There are also "compressed air" and "oxidising water" filters, and "Anderson's revolving purifier" in use. They don't require more than a passing mention.

Action of Light.

The germicidal effect of light on bacterial life in water has, perhaps, as pointed out by Professor Frankland at times, been exaggerated; but there is evidence beyond question of the beneficial effect of the percolation of light through water areas. The extent to which light can penetrate depends very largely on the clarity or otherwise of the water.

Professor Frankland's conclusions "There is no question that light, and more especially sun-light, has a deleterious effect on bacteria in their vegetative and to a less extent in their forms.

"This deleterious effect can be produced by light irrespectively of the rise in temperature which must accompany direct insolation unless special precautions are taken.

"It is however the most highly refrangible rays of spectrum that are the most injurious to bacterial life, the ultra-violet being the most and the infra-red the least powerful in this respect, a circumstance which clearly indicates that the phenomenon is due to chemical action.

"In its special connection with the bacteriology of the water we must therefore recognise in sunshine and, to a slight extent also, in diffused daylight a powerful bactericidal agency but the importance of which there has been considerable tendency to magnify and exaggerate."

Purification by Ozone.

Dr. Erlwein of Berlin, speaking on the purification of water at the 43rd Annual Meeting of the German Union of Gas and Water Engineers, said that water which has never travelled underground since it last fell as rain invariably needs purification both from suspended organic matter and from pathogenic bacteria. He advocates the treatment of water by ozone. It is not only a bactericide, but it also frees water so perfectly from iron that it may well be used for that purpose alone. Dr. Erlwein describes the process for preparing ozone and also cites instances of Wiesbaden and Paderborn where water is purified successfully by ozone. In Western Philadelphia raw Schuylkill River water contains as many as 2,500,000 bacteria per cubic centimetre. After rough straining this number is reduced to 250,000 and after treatment by ozone from 5 to 55.

Bombay water-supply is not so very impure as to require treatment by ozone.

Standard of Purity.

I now come to the last question in connection with water-supply and that is what standard of chemical purity could one give for all these waters? Many attempts have been made to find a standard. None has as yet been found. Just as in connection with the rate of filtration it must be said that every water has its own standard.

A water may be quite free from the specific pathogenic bacteria, but it may have been contaminated with substances prejudicial to the general health when imbibed with the drinking water yet not capable of producing any specific disease.

Organic Matter.

The presence of organic matter is held with very good reason to indicate that the water has been contaminated.

Dr. Thresh says that when a water is known to be fouled by sewage or known to be liable to such pollution any form of examination is superfluous. It is, as said elsewhere, that the analyst should either himself be acquainted with the surrounding circumstances of the place whence the water is derived or should be fully informed of them. For large water-works it is also highly desirable that all gathering grounds should be purchased by the Company or the Corporation supplying the water.

As regards Bombay the water-supply is drawn from

Vehar, Tulsi and Tansa Lakes. The areas of the gathering grounds of these three lakes are as follows :—

Tansa { 1,120 acres Municipal.
30,080 acres non-Municipal.

Vehar ... 2,500 acres non-Municipal.

Tulsi ... 1,385 acres Municipal.

It will be seen that about 30,080 acres of ground do not belong to the Bombay Municipality in the case of Tansa Water Works, and the whole area of the gathering grounds in the case of Vehar water does not belong to the Municipality. That ought not to be the case. The Bombay Municipality should purchase outright all the areas of the gathering grounds of their lakes which do not belong to them.

It is by no means an easy matter to pronounce an opinion on a sample of water from the consideration of the results of chemical analysis. There is a great tendency to form an opinion on the amount or presence of a single constituent which leads to erroneous conclusions.

Thus, if a water be judged on the amount of nitrates it contains without regard to the other constituents, a pure water from a district where the soil contains much nitrates would be considered as impure although the nitrate may be due to soil peculiarities, and chalybeate waters of undoubted purity often contain a high proportion of albuminoid and free ammonia independently of admixture with any sewage. Again, it is quite possible that a water contaminated with sewage may have undergone sufficient filtration and nitrification to convert all ammonia into nitrates and yet from the presence of undestroyed bacteria it may be utterly unsuitable for potable purposes. Again, should any delay occur in examination of sewage-contaminated water the ammonia may oxidise into nitrates in the bottles. Dr. Thresh, an analyst of much experience, says that the presence of organic matter may be chemically demonstrated, but, inasmuch as its nature, whether poisonous or innocuous, is beyond the power of the analyst to reveal, though as pointed out elsewhere in this paper, the results of Sir Edward Frankland's conclusions, it is obvious. Dr. Thresh says that a mere chemical analysis may be worthless or even misleading. Indeed, he says, there is no chemical test which can as yet distinguish between the disintegrated and dissolved proteids whether they are of vegetable or of animal origin and of their actual chemical constitution he is ignorant.

Chlorine.

Again the determination of chlorine is considered to be almost useless for detecting admixture of sewage or impurities of animal origin. Waters contaminated with sewage no doubt always contain chlorine, but as sewage only contains on the average 5 grains per gallon and as chlorine is a normal and very variable constituent it is evident that only a very large admixture of sewage matter would render the chlorine in any way abnormal. Thus a water might contain 10 per cent of ordinary sewage, giving 0·5 per gallon which is an amount not unusual in a pure sample.

The question now arises on what principles should a scale of potability be drawn out. Increase of chlorine may be due also to soil peculiarities. For Bombay the late Health Officer Dr. Weir thought that water was potable when the following were not exceeded :—

Free ammonia—0·02 part per million.

Albuminoid ammonia—0·15 part per million.

Chlorine—one grain per gallon.

The present Health Officer submits the scale as compared with the scale of potability of the London Water-supply Companies. The comparative results of the analysis are not so very good inasmuch as Bombay water-supply comes from artificial lakes and ought to be purer than the water-supply of London and it is very curious why we should not get better results here in Bombay.

Chemical and Bacteriological Examination Necessary.

It was at first sufficient that the results of chemical analysis would guarantee the purity of water, but since the development of the germ-theory of disease it is found necessary that a sample of water should be both examined chemically and bacteriologically.

For the necessity of bacteriological examination of water, an instance in point is related by M. Roux: A certain restaurant at Lyons was renowned for the fresh and palatable character of its well water, so much so that many people repaired to this establishment for their repast on this account. It happened that a great many of the waiters who ate and slept at the restaurant fell ill of typhoid fever one after the other. The water was examined chemically and was found to be excellent. Bacteriologically it was found to contain enormous numbers of Bacilli Coli Communis, testifying to its contamination from a neighbouring privy. The well was closed and no more typhoid occurred.

It was at the instance of the writer of this paper that the Bombay Municipality gives the monthly report both chemical and bacterial analysis of the water-supply of this City.

No real Standard for Indian Waters.

There is a lack of reliable standards and the want of a scale of potability for Indian waters.

Bacteriological Examination of Water.

In absolutely pure water bacteria will not live. It becomes a physical impossibility for them to do so. All the bacteria in a water are not noxious. Organic matter in the water is simply their food. Pathogenic or disease-producing bacteria may not be in the water at all, but when there is much organic matter in water, and especially from animal sources, the bacteria thrive in it if they should reach it.

When we say that a certain water contains 2,500 bacteria per cubic centimetre of the water it means that there is considerable organic matter in the water.

Koch's Bacterial Standard for a good Water.

Koch states that a good water for drinking purposes should not contain more than 100 germs per cubic cen-

timetre. but obviously this is intended to be taken with considerable limitation. A deep well water ordinarily containing only 10 to 20 per c. c. might be dangerously polluted if the germs rose suddenly to 80 or 100 per c. c. without any adequate explanation.

It should be remembered that the circumstances that influence the multiplication of bacteria in water are very complex. One should take into consideration the nature of the water, the nature of the bacteria present, the time that elapses between the taking of the sample and the preparation of a plate cultivation and the temperature.

Care to be taken in Collecting Samples of Water.

(*a*) Water samples should always be collected in sterile bottles by the analyst himself as far as possible or his immediate assistant according to the great authority, Dr. Houston, (*b*) the bottle should be packed in ice to inhibit further growth. The ideal method is to make the cultures immediately on collection and if possible on the spot and they should not be more than 12 to 15 hours in transit before culture is made.

After 24 hours it is hardly worth while to make the count. The sample must always represent the source.

Only 99 p. c. Microbes are arrested.

It is said that under the most perfect conditions only 99 p. c. of microbes can be arrested. The question naturally arises, what becomes of the escaping microbe? Nobody can deny the great value of filtration, but attention should be at the same time called to the " missing microbe."

Colon Bacilli in Bombay Supply.

These are bacteria found in the intestine of practically all mammals. They are not normal in water. Though they live a considerable time (weeks) in water, it is not their normal habitat. Every month the report of the bacterial analysis of water is presented to the Bombay Municipal Corporation, colon bacilli are there. These bacilli belong to the same group as the typhoid, paratyphoid and paracolon bacilli. It is very difficult to deny that under suitable conditions they take up pathogenic properties.

At any rate when they are found in 1 c.c. we should in the present state of our knowledge look with suspicion on the water containing them. They are practically always found in sewage polluted waters and these usually contain typhoid infection.

The colon bacilli live in the same conditions as typhoid bacilli and, when they are present, it is a presumptive evidence of a pretty strong kind that a water containing it may give rise to typhoid fever.

Colon Bacillus versus Filtering Plant.

The discovery of it finds its greatest use in the estimation of the value of filter plants. A filtering plant that will let them through will likely let typhoid bacillus through. A plant that will exclude them from its effluent can be looked on as efficient to hold back the typhoid bacillus.

The finding of colon bacilli in water will put us on possible pollution. As the filter-beds of the Bombay water-supply let through colon bacilli, they require looking into. Again, in the Vehar lake supply of Bombay cholera vibrios are sometimes found, more especially when the water in the Vehar lake falls to a very low level.

B. enteritidis sporogenesis, Streptococci and Staphylococci are also occasionally found in the Bombay water-supply probably owing to the intermittent supply and leaky pipes.

Conclusions.

With all chemical and bacteriological examination of a sample of water, the analyst should consider (*a*) the nature of the surroundings of the spring or well, (*b*) the character of the gathering ground, (*c*) if the water be from a small stream, brook or a river, the character of its banks (showing whether gross pollution takes place in the immediate neighbourhood) and if taken from a public supply or from a house cistern, its condition, situations, &c.

Dr. Thorne, Medical Officer of the Local Government Board in England, impressed the necessity of taking notice of the gathering grounds and source of a water-supply in the following words :—" No opinion as to the potability of water derived from chemical and bacteriological examination should be complete unless accompanied by a survey of the source by a sanitarian."

(*a*) That Indian waters cannot be judged of by western standards.

(*b*) That the use of a scale of potability is a great help to the sanitarian and all who have to do with questions of water-supply.

(*c*) That the analyst should be furnished with all possible information as regards reasons for analysis and environment. He should also be told on what his opinion is wanted.

(*d*) That the water sample should be forwarded to the analyst with as little delay in transit as possible.

DISINFECTION OF WELLS BY PERMANGANATE OF POTASH.

Whenever cholera breaks out in a town or a village drawing its water-supply from a well or wells, or whenever in a well water the cholera microbe is found, that well should be treated with permanganate of potash. Usually about an ounce of permanganate is placed in a chattie and lowered into the water of the well till the whole of the permanganate in the chattie is dissolved. This gives a peculiar pink colour to the water in the well. If there be a large amount of organic matter in the water the pink colour produced by the permanganate soon vanishes, and this process should be repeated till the water retains the pink colour for about 12 hours. Some add with permanganate of potash hydrochloric acid; there is no danger in drinking well water thus rendered slightly pink.

"WATER-SUPPLIES."

MEASURES FOR ENSURING PURITY, &c.

By Dr. K. E. DADACHANJI.

Water is not only the chief constituent of the body, but it is also, what is more important, the vehicle through which those innumerable chemical changes taking place in the tissues are conducted.

Without water no elimination of waste products can take place by way of skin, kidneys or alimentary canal. It is truly the basis of life, for, without it, even in the midst of plenty of all other foods, life cannot be sustained for any length of time. As a matter of fact, entombed miners who had water but no food lived longer than those who had food but no water.

When we consider that water is required by every tissue of the body for the elimination of the poisonous products of waste by the skin and kidneys, to say nothing of the amount demanded by the various glands engaged in digestive operations, we can only marvel that so little as we consume can do so much.

In those people who live on a short water-supply, urea and other waste matters accumulate in the tissues of the body giving rise to rheumatism, gout, dyspepsia and kindred ailments merely for the want of a solvent to carry poisons out of the systems.

One of the most important branches of engineering affected by meteorological conditions is water-supply, because the principal source of water-supply is the rainfall. The amount of average annual rainfall and the capacity of the soil for collecting and storing it are matters for earnest consideration in securing for communities an adequate and pure supply of this most necessary substance.

One professor recently predicted that the time will come when there will not be enough water remaining on the globe to support human life. This contingency may, however, be viewed with a certain amount of equanimity for at least some generations to come, especially when we consider that some three-fourths of the globe is covered with water to an average depth of some two miles.

There is sufficient water on the globe to last for generations to come, but the point is how much of this is available for the supply to large communities. As in he case of Niagara and other falls, there is so much waste going on.

The question therefore is how to conserve our water-supplies and at the same time give a pure and abundant supply for constant use at a cost within the reach of all.

It is with this view in mind that the early civilized communities, in particular the Romans, executed many gigantic engineering works for securing to Rome and other cities an ample supply of pure water and many of their aqueducts still stand to excite our wonder and admiration at the marvellous skill they displayed in the excavation of gigantic masonry structures.

It is from the impetus given by such works that the science of hydraulics has been built up in later years. Torricelli and Bernoville and the labour of successive investigators accumulated a vast store of data, upon which the modern science of hydraulics is based.

It is impossible to treat in this place of the results of the researches, laws of resistance to flow in pipes and in bends, velocity, measurements of discharge of pipes and conduits, &c.

Water-levels and Death-rate in Children.

My object in alluding to this is that the time has now arrived when it is necessary to carry on experimental work in this branch of engineering, and for this purpose hydraulic laboratories in different presidencies of this great continent should be established, where also a record should be kept of the quantity of water percolating into the ground by means of percolating gauges, and levels of underground water should be marked, because it has been found that the deaths of children under five years of age, after excluding deaths from diarrhœa, is inversely proportional to the quantity of water present year by year in the ground, that is, when there is a large volume of water in the ground, the death-rate declines and with a small quantity of water the death-rate is considerably augmented, so much so that if the death-rates and the water-levels are plotted on the opposite sides of a diagram, they are indicated by parallel lines. Even the death-rate from diarrhœa is dependent on the level of underground water.

I will divide my subject as regards the water-supply in the following order :—

(1) Water-supplies to towns and cities,
(2) To villages, and
(3) Household water-supply.

Water-supply to towns and cities.

(*a*) This is effected by means of rivers, as at Agra, Delhi, &c., (*b*) from canals, as at Meerut, (*c*) from a series of wells, as at Amritsar, Ahmedabad and Surat, (*d*) from tanks as at Ajmer, and (*e*) from artificial lakes, as Vehar, Tulsi and Tansa Water Works of Bombay.

Water-supply from Rivers.

(*A*) In the case of the water-supply of a town or city from a river, the following precautions should be taken in order to safeguard the sources of contamination :—

(1) There ought to be no villages or cities 10 miles from the intake. If there is one as at Agra, water gets contaminated from the washings of dejecta, &c., on the bank after the rise of the river waters or after rains.

(2) If the river changes its course a channel should be dug by coolies to the pump well and thus contamination of the water by dirty feet and hands of the coolies should be guarded against.
(3) No ships and boats should be allowed to anchor near or above the water works.
(4) No fishing should be allowed near the intake.
(5) Half burnt bodies of adults and dead bodies of children should not be allowed to be thrown into the river.
(6) Cattle should not be allowed to graze near the intake.
(7) Intake should be located above a place where the tide has no effect on water, otherwise, as in Surat at certain times of the year, salt water gets in the intake.

Water-supply from Canals.

(*B*) In the case of the water-supply of a town or city by canals the following sources of contamination should be guarded against :—
(1) There should not be any village or town above the water works.
(2) The canal should not pass through the heart of the city as in Delhi.
(3) Ships and boats, frequenting the canal, foul the water by the discharge of excreta from boats.
(4) No fishing near the water works should be allowed.
(5) No grazing of cattle should be allowed.

Water-supply from a series of Wells.

(*C*) In the case of the water-supply from a series of wells to a city or town as at Amritsar, the following precautions are necessary :—
(1) The well should be dug on sites where there had been no human habitation for at least some years.
(2) They should not be dug near manured grounds.
(3) As far as possible they should be at least 2 miles from the city.
(4) There should be no dwellings near the pump-houses and the dwellings must be at least 100 yards away.

(*D*) In the case of the water-supply from tanks as at Ajmer, the following precautions are necessary :—
(1) There should be no huts or houses near the tanks.
(2) People should not be allowed to lower their dirty vessels into the tanks.
(3) They should not be allowed to wash their clothing and even dhobies should not be tolerated.
(4) The bank of the tank should not be allowed to be fouled.
(5) No fishing should be allowed.
(6) No grazing of cattle should be permitted.

(*E*) In the case of the water-supply from artificial lakes as for the City of Bombay, the following precautions are necessary :—
(1) No village should be allowed to grow up within 10 miles.
(2) No officer or servant should be quartered within $\frac{1}{4}$ mile of such lakes ; their residential quarters should be so situated that household washings and discharges should not get into the lakes.
(3) No fishing or shooting should be allowed.
(4) No picnic parties or bathing should be allowed.
(5) There must be a constant dredging to remove vegetation.
(6) No cattle grazing should be allowed near the lake and also no cultivation by manure should be allowed on the gathering ground of the lakes.
(7) In order to prevent cultivation there should be a reasonable afforestation. The Liverpool Corporation have converted their gathering grounds into forest lands.

Water-supply of Villages.

Villages are supplied with water from rivers, tanks or wells. As regards the safeguarding of the contamination of the water-supply of villages from rivers, brooks, ponds, or tanks, the same precautions should be taken as in the case of the water-supply of towns and cities by rivers and tanks.

Village Water-supply by Wells.

As regards the water-supply of a village from wells, the matter being very important to the Indian communities requires a very careful consideration.

The question of wholesome underground water has even a greater importance than the supplies taken from streams, tanks, rivers or impounding reservoirs which have been exposed to the influence of light and air.

There is a vast population in this country still supplied with water from sources which may be looked upon as extremely dangerous to public health, such as wells of towns and villages.

It should be borne in mind that no underground water can be wholesome unless it is derived from sources in which the soil is clean.

It is a singular fact that, in all the great epidemics of typhoid fevers in Europe, the water-supply implicated has either been practically supplied from underground sources or from sources in which the impurities have been in immediate direct contact with the ground. Hence it is necessary that the use of water from surface wells in towns and populous places should be as far as possible prohibited owing to the impossibility to avoid the multiplication of sources of pollution.

There is no doubt that in many cases good water is procurable from the great geological formations of the chalk, and sandstone ; but even these sources of supply are liable to pollution of a dangerous character if the site selected for procuring the water is not located in a favourable situation.

A very large proportion of the water-supply of rural districts is procured from wells sunk in superficial deposits which more or less cover every geological formation.

The quantity of water will entirely depend upon the position in which the well is located with regard to its underground area, and the purity of its water will also entirely depend npon the freedom from sources of contamination.

Underground Water-supplies from Rainfall.

It is believed that all underground water-supplies originate in rainfall, but it should be remembered that only a portion of the rain passes into the ground so as to be available for future underground water-supplies.

Late Rain contributes the Underground Supply.

The popular belief in India that the early rain has no effect whatever in replenishing the underground sources of the supply of wells, but that such is effected by the late rain, is proved to be well founded by experiments made by Mr. Baldwin Latham and other sanitary civil engineers.

Fluctuating Water Line.

It has been ascertained that all wells when measured by percolating gauges have a "*fluctuating water line.*"

As the principal source of the water-supply of several towns and cities and villages is the supply from wells, it is necessary to take notice in this place of the existence of a fluctuating water line in wells because it has a considerable influence on the health of the communities where the water is liable to excremental contamination, as, in the space between the high and low water levels, the germs of disease are believed to undergo that development necessary for the propagation of disease.

Dr. Poore's "Living Earth."

In this connection, it is fit to notice the opinion of Dr. Poore, who says that the upper three feet or so of the soil swarms under ordinary circumstances with bacteria whose function is to break up and oxidise dead organic matter into mineral salts, chiefly nitrates, thereby rendering it fit for absorption as the food of plants while innocuous to animal life. The more highly cultivated and worked the soil, the greater its power, which is however lost if the soil become sodden or water-logged.

Dr. Poore calls this upper layer of 3 feet or so of the soil "the living earth."

Below the depth of 4 feet or between 4 feet and 6 feet the bacteria disappear and Dr. Poore calls this soil "dead." Besides the fluctuating water line in a well another feature with reference to underground water has been ascertained and that is that underground water has an "inclined surface."

Inclined Surface.

It is impossible for water to stand at an inclined surface without movements and it should be remembered that movement of water is in particular directions and consequently water which is receiving its impurities in the higher parts of the stream would be likely to convey these impurities to a considerable distance depending upon the extent of the area and the amount of the impurity which is received. As a rule, underground water follows the same course as surface flows and is governed by the same laws as the surface streams, but there are exceptions to this rule.

Mr. Baldwin Latham has proved that there are cases where the water runs directly out of one valley into another through intervening rising grounds. A well-known case occurred at Lausen, near Basil-Switzerland, in the year 1872, where the morbific matter of typhoid was carried a distance of a mile or more through a hill to a village on the opposite side of the hill. This was proved by what is known as the "Lithia test."

"Lithia Test."

Lithia is used for this purpose because it is harmless and gives a distinct band in the spectrum and thus an infinitesimal quantity of lithia can be detected by spectrum analysis; salt and fluorescein are also used for the same purpose.

Effect of pumping on Underground Water.

Another thing in connection with the underground water worth noticing here is the effect of pumping on underground waters. The pumping has a very considerable influence in reversing the flow of streams. It lowers the water line below the ordinary level and thus impurities are added ; salt water from tidal rivers might also gain access thus, as was the case in Velacha Water Works at Surat.

In connection with the underground water-supply, many investigations have been made showing that water moving in a particular direction is found outside a village or town to be of a pure character, but that as it gradually passes into a populous district, its quality begins to suffer, and ultimately it becomes extremely polluted. In such water an increase of nitrates has been found. The late Dr. Parkes in his work on Hygiene pointed out that the indications of nitrates in water were always suspicious and it should be observed with reference to this matter that the Rivers Pollution Commissioners in their Sixth Report gave an analysis of the Caterham Water Works at the top of the North Downs containing ·027 parts in 100,000 of nitrates, while in Croydon Wells in the lower part of the valley the nitrates increased to ·551 parts in 100,000 showing 26 times as much nitrates in one well supplied as in the other owing to the water passing through a more or less populous district the subsoil of which is polluted.

The late Professor Liebig in his investigations found in the case of the wells of Giessen, that there were nitrates in the wells of Giessen, but not in wells located 200 or 300 yards outside the town.

Outskirt Wells.

This important point has great bearing as regards the water-supply of our villages and towns. We know that, in many parts of this country, wells for drinking purposes are sunk on the outskirts of villages and towns. Wells for other domestic purposes are sunk in the heart

of towns and villages. The consideration that the water after passing through a populous place becomes polluted seems to have intuitively worked on the mind of villagers and townsmen to locate the wells for drinking purposes outside the villages or the towns.

Deep Wells.

It is known that water in the wells may be supplied from impure sources or may be affected in purity by moving through underground passages. Even in the case of a deep well the same pollution may occur, and yet this appears to escape general attention as it is generally sufficient to say that the water is taken from a deep well and there will be no danger of contamination and there the inquiry ends.

Jews and Poisoning of the Wells.

Through the erroneous idea of the wholesomeness of the water from a deep well various diseases have arisen, and how often in the past have the Jews and others been unjustly accused of poisoning wells, though the unwholesomeness of the water arose from the pernicious practices of polluting the sub-soil by those who accused the Jews and other persons. The fact that a well may be of a very considerable depth is no safeguard against an outbreak of epidemic disease like typhoid fever. This is clearly shown by an outbreak of fever which occurred in 1894 in connection with a deep well, the water from which supplies the Caterham Asylum and also at the time supplying the Guards Barracks at Caterham. In both of these establishments typhoid fever broke out. It appeared that the drains of the Asylum were in a very leaky condition and that sewage passed out of them into the sub-soil which was chalk. By the Lithia test mentioned above, it was found that the well was contaminated by sewage. The well was a very deep one, over 462 ft. to the bottom, and it was ascertained that the water line was often removed over 350 feet from the surface.

Protection of Wells.

The surface and shallow wells are liable to be contaminated by percolation, surface washings and other collections of filth. They should not be dug near privies or cesspools. Deep wells are exposed to contamination of a somewhat similar character especially when sunk in chalk, limestone, or sandstone, where steyning is looked upon as superfluous. No doubt such rocks, unlike clays and gravels, are self-supporting but extremely pervious and chalk is further apt to be traversed by fissures often of great length by which sewage may enter the well at any level between the surface of the ground and the bottom.

Lining of the Wells.

All such wells should be lined with a facing of good hydraulic cement from the mouth to the depth of at least 20 feet or to a level below some impervious stratum. This however applies to deep wells or the deep portion of compound wells, for with driven or bored wells it is sufficient to leave the tube *in situ* to obtain the most perfect protection against what may be called lateral contamination. But there is another source of pollution to which all wells, shallow or deep, are exposed, if not covered in and fitted with wind mills or pumps. Open wells are inevitably polluted by surface drainage unless the brick-work be carried to about a foot above the ground level and even then, unless the surface of the ground around be well paved with slabs of stone or with concrete, the bucket, lotah or chattie every time it is stood on the wet and trodden earth takes up a certain amount of dirt which it conveys to the well when it is next let down.

Jonet's Safety Water Elevator.

For such cases an ingenious contrivance known as "Safety Elevator," Jonet's patent, has been successfully used. In India where owing to the apathy of the natives the grossest pollution of the water-supplies renders the wells almost without exception suspicious, this apparatus would be invaluable; or charitably disposed gentlemen can provide special vessels, as is the case in some villages, to draw out water from the wells. There is a common practice of throwing into wells, sugar, flowers, cocoanuts, &c., also throwing old and torn sacred threads, the Janois of the Hindoos and Kustees of the Parsis. This practice also should be put a stop to. Owing to the marked difference in habits I would consider it a good idea to separate wells for high caste and low caste people.

No Kosh should be allowed in wells used for drinking purposes, as while the bullocks pass along the incline, dragging the rope on the ground, all sorts of dirt, dung and deposits are taken into the well. The washing of clothes on the paved portion of the well and close-by it should be prohibited.

Wells should be cleaned at least every six months because very often old shoes and illegitimate babies are thrown into them.

It is a very bad practice to allow trees to grow near the wells as the leaves might fall into the wells and thus pollute them. No lining of the wells by means of offshoots of banyan tree and other woods should be permitted.

Dr. Woodforde of Reading recommends that all shallow wells should be lined with large glazed earthenware-drain pipes set flange downwards and joined with cement and surmounted with Jonet's Safety Elevator. He says that by this precaution we should hear no more of typhoid fever or other illness in villages and districts, since the pollution of such wells would no longer be possible.

Whenever it becomes impossible to remove the source of pollution, the contaminated wells will have to be closed and other sources found. In such cases a public supply should as far as possible be provided by the District Board for a group of villages; or arrangements should be made for a water-supply with a company or a Corporation supplying a neighbouring town.

Household Water-supply.

This is usually effected by sinking wells in the compound or back-yard of a house, or by constructing

masonry tanks (small reservoirs) known as "Tankas" in some part of the house. The same precautions should be taken for their preservation as in the case of village and town wells and tanks.

Water Pollution by Graveyards.

The contamination of wells and water courses in and about cemeteries is a source of far greater danger than is generally supposed. This water has a sparkling crystal-like brilliancy due to the large proportion of nitrates and nitrites contained therein. It is a well ascertained fact that the surest carrier and the most deadly fruitful nidus of Zymotic contagion is this brilliant enticing-looking water charged with nitrates which result from decomposition. The writer of this paper has also bitter experience of this crystal-like water. In my Nasik Road Estate I sank a well which went to the depth of nearly 40 feet and the water was sighted by the well diggers. They began to praise the brilliancy of water and drank it to their heart's content for several days and the result was that those who drank that water suffered from gastro-intestinal symptoms. The terrible scourge of cholera in London in 1854 was believed to have had its origin in the upturning of the earth in which the plague-stricken victims of the year 1665 had been buried, and in drinking the water that came from the old Broad Street pump, the water being drawn from an old churchyard.

We find it stated in the Report of the London Board of Health for 1850-51 that cholera was especially prevalent and fatal in the vicinity of graveyards.

Again according to the British Medical Journal when plague visited Barbary in 1873 the people of Marah who obtained their supply of water from wells in proximity to a burial ground were attacked, while the residents of another portion of the town, where water from other sources was used, escaped.

During the Peninsular War the encampment of troops had frequently to be changed on account of sickness occasioned by the use of wells near the repositories of the dead.

With the local underground water-supply it is always fraught with gravest danger to allow earth burial in the midst of towns and villages. This practice is dangerous to survivors. It is owing to this grave danger to the health of communities that the Parsi religion strictly prohibits the system of earth burial.

It would almost seem that Shakespeare was inspired by a prophetic sanitary wisdom when he referred to—

> "The very witching time of night,
> When graveyards yawn, and hell itself breathes out
> Contagion in this world."

Thus there is a great danger of the poisoning of the water by graves, so much so that laws exist in Italy prohibiting the opening of a well within 300 feet of any place of burial; in France within 100 yards and in some German States it is forbidden by law to dig a water well nearer than 300 yards of any grave.

However extravagant the above remarks may appear to some, there is not the least doubt that the wholesale burial of human remains which takes place daily in any populated districts, poisons the earth, air and water. The greatest evil is the contamination of a water which eventually finds its way into the most inconceivable sources and in many cases comes in close contact with the water-supply of our towns.

Lead Poisoning and Water-supply.

It may be as well to note that the waters of some wells have been shown to have the property of acting upon lead and producing lead poisoning amongst those who use them when the water from them is conveyed through lead pipes or lead pumps.

Acidity.

It has been shown that in some waters there is acidity which is due to humic or other organic acids of vegetable origin. Dr. Houston carried on numerous experiments and proved beyond dispute that the acidity to which water owes its plumbo-solvency has its origin in peat. He thinks that it is also associated, at all events in part, with the presence of acid producing bacteria in the peat. Mr. Aspinall Marsden says that "out of 58 reservoirs recently examined, no less than 35 contained acid water possessing the property of dissolving lead." In India such acid waters do exist, but unfortunately for want of chemical analysis in the districts they are not taken notice of. Besides in villages and some towns water is not supplied by lead pipes and hence in many instances the danger of lead-poisoning is averted.

This acid property of water has the dangerous property of vigorously attacking lead pipes giving rise to, when present in a sufficient quantity, lead poisoning, but when the acidity is not quite sufficient to produce this, it causes anaemia, dyspepsia, or a weakened state of health. Even the slightest contamination by lead should not be tolerated.

Quantity Dangerous.

Dr. Houston has expressed his opinion that "No water should be used for drinking purposes which contains more than one part of lead per million or any trace, however minute, indicates danger."

Remedy.

As a preventive of excessive acidity Dr. Houston seems to specially favour treatment with sod. carbonate whether carried out at water works or the laboratory, but in practice it might be cheaper to resort to a preliminary lime or combined lime and sand filtrating treatment and then to supplement this finally with the further addition of sod. carbonate in nominal quantities. It has also been suggested that addition of chalk with aluminoferric will counteract the effect of the acidity.

Lead Poisoning in Water-supply by Electrolysis.

Mr. Earnest Stanhouse recommends the use of tin-lined pipes to obviate the risk from lead contamination. In connection with the lead poisoning by the water-supply it must also be borne in mind that there is more danger from the escape of electricity from electric cables

into lead water pipes and into iron pipes producing plumbism in the former case and erosion in the latter than has been hitherto conceived. Hence it is necessary to take precautions in laying underground electric cables in large towns and cities where water is delivered by means of lead or iron pipes.

Selection of Site for a Household Well.

In single isolated houses, by observing the direction of the underground flow of water, we may always select a site for a well that shall be in the upstream side of the flow, and the cesspool may be placed with impunity on the lower side of the well. In many cases unhealthy houses have been made healthy by moving the well from one side of the house to the opposite side and so escaping the impurities from the cesspool passing into the well.

A SUMMARY OF BOMBAY WATER WORKS.

Bombay Water Works.

The City of Bombay is supplied with water from three different lakes situated in Salsette far outside the City. There is a fourth lake provided, *viz.*, Pawai, but the water of this is only used for industrial purposes, near the lake and not distributed in the City.

Vehar Lake.

The first of these lakes is Vehar. The area of its gathering ground is 2,500 acres; it has got three dams the height of the lowest draw-off on the T. H. D. is 232·15, its capacity for supply when it is full is 8,800 million gallons; mean rainfall during the past several years comes to 84·70 inches; mean evaporation comes to 36⅝ inches; depth of lowest outlet below over-flow level is 32 feet; greatest depth of water stored is 59 feet.

This is the first of the lakes constructed for the supply of the City. It is 15½ miles from the Town Hall of Bombay. It was finished in 1860. The water of this lake is conveyed to the City by means of cast-iron pipes of 24″ and 32″ in diameter laid generally above the level of the ground. The 24″ pipe discharges directly into the distributing mains; and the 32″ into the Bhandarwada Reservoir.

Tulsi Lake.

The second of these lakes is Tulsi. The area of its gathering ground is 1,385 acres. It has two dams, the height of the lowest draw-off on the T. H. D. is 400; capacity available when the lake is full 2,306 million gallons; mean rainfall comes to 103·82 inches; mean evaporation is 36⅝ inches; depth of lowest outlet below overflow level is 57 feet; greatest depth of water stored is 57 feet. It was constructed in 1879, and is 19 miles from the Town Hall of Bombay. The water is brought into the City by means of cast-iron pipes 24″ in diameter laid generally above the level of the ground, and discharging into the Malabar Hill Reservoir.

Tansa Lake.

Tansa is the largest lake. The area of gathering ground, 33,600 acres; there is only one dam; height of lowest draw-off on the T. H. D., 380 feet; capacity available for supply when the lake is full, 18,600 million gallons; evaporation is about 3 feet; depth of the lowest outlet below overflow level is 25 feet; greatest depth of water stored is 110 feet; average rainfall comes to 106 inches; it is 58 miles from the Town Hall of Bombay. It was finished in 1891. The water is brought into the City by means of a masonry conduit as far as practicable. The syphons across the valleys are of cast-iron pipes, 48 inches in diameter, laid generally below the surface of the ground.

Quality of Water.

The quality of the water of these lakes should next be considered. Tansa water is of good quality, but now-a-days one finds when on the Tansa lake that there are quantities of suspended particles of vegetable origin in the water. It is time that Tansa water should be filtered, or, if possible, the vegetable matter should be dredged.

Next to Tansa in quality is Vehar water. Vehar is the oldest lake and there is an immense amount of vegetation growing in the water at the northern portion of the lake. Though the whole of the water of Vehar is distributed after filtration, the filters not being efficient, it carries a risk of pollution. The vegetable matter in Vehar lake, if possible, should also be dredged or the filter should be made more efficient.

Tulsi stands last in quality. The full complements of filters at the Malabar Hill reservoir now being provided and finished, the whole of Tulsi water will be distributed after being purified by filtration.

Storage Reservoirs.

Storage reservoirs ought to be of such a capacity as to hold a water supply for 8 days. These should be cleaned every 6 months, and if there be much vegetable matter every three months. Mud and dirt removed from storage basins should not be allowed to collect near the basins but should be disposed of at once in a place away from the water works.

There should be no disturbance of water of the lakes by shooting, fishing or by picnic parties.

As regards the storage basins of filtered water, this is generally constructed underground and on it a garden is made. Gardens require manuring and watering and if the roof of the clean water storage basin is not perfectly water-tight there is a danger of polluting filtered water. Again ventilators are generally provided on the top of the clean water basins. These ventilators ought to be placed 3 or 4 feet above the ground in order to prevent large washings and other foul things entering the ventilators and thus polluting the filtered water.

As a rule no garden should be allowed on the roof of the clean water basin; if anything is to be allowed, it should be a lawn.

The walls of the clean water reservoir should be whitewashed at least every 6 months.

WATER MAIN AND DISTRIBUTING SERVICE PIPES.

While laying the water mains it is always necessary to examine the nature of the soil. If it contains saline-

matters, mains are sure to be corroded. The main should be laid on a firm basis so that by the lapse of time there will be no subsidence and thus no crack or leak is produced.

Water Mains and Service Pipes.

Joints of the mains should be well-made and they should not be leaky. They should not be made near the drains because there is great danger of contamination as in the case of Bombay Water Works when such contamination occurred near Currey Road. No water main or pipe should be made to pass through any drain or storm water channels, nor should they be laid close to the drains.

If the supply is intermittent, and the pipes are corroded and leaky, there is always a danger of water pollution from the polluted sub-soil as in the case of Bombay water-supply; a case occurred in the district of Kamatipura about two years ago. Several cases of cholera occurred in the locality where the service water pipe was corroded and passing through drains. That pipe was removed and cases of cholera were thus stopped. In this connection the following extract from a memorandum issued by the Local Government Board of England will be useful:—

"The liability of leaky water pipes to act as land drains to receive foul matters as well as land drainage through their leaks is not to be overlooked. Such leaky pipes running full of water with considerable velocity are liable to receive by lateral insuction at their points of leakage external matters that may be dangerous. The latter fact is not recognized so generally as it should be and ignorance of it has probably baffled many inquiries in cases where water services have in truth been the means of spreading disease."

While repairing mains and pipes no wooden plug or any patch-work likely to lead to the contamination of water should be allowed.

House service pipes should not be near the privies and cesspools. Their joints should be frequently tested. Lake water should be examined chemically and bacteriologically before and after the rains on the spot.

During an epidemic, water should be examined as frequently as possible, perhaps every day.

Hydrants.

Water hydrants should not be of the old ball pattern, because this ball hydrant is found responsible for the presence of water fleas and insects in water. As long as the pressure is maintained this hydrant does its work admirably but with a diminution of pressure the ball falls and causes an aperture into which dust finds its way and animalculæ are engendered. In Bombay wherever there are ball hydrants they should be replaced by what are known as valve hydrants. Reports of the bacteriological examination of the Bombay Water Supply show that there are cyclops quadricornis in the water owing to this cause.

Constant vs. Intermittent Supply.

It is common knowledge that in large water-works as for the City of Bombay, with so many mains and interlacing service pipes undergoing decay and deterioration, and, in the words of the late Mr. Santo Crimp, which are laid in ground polluted with sewage, there is a grave risk of pollution of water supply owing to the intermittent mode of the water supply of the City. There are also, he says, further risks of pollution of the general supply due to the taps being left open in insanitary dwellings or to the water drawn from the taps being stored in utensils of various kinds due to the short supply. Hence it is necessary that the constant supply should be introduced into our City.

Mains should not be tapped on their route.

It is highly necessary that water mains should not be allowed to be tapped on their route, because this means so much loss of pressure.

It is contemplated to duplicate Tansa Mains to bring into the City a large additional supply from Tansa. In the words of great experts like Midgely Taylor and Strachan, before that time arrives, the direction in which the City has developed will be ascertained, which feature will have a material bearing upon the extent of the new sewers which would be required to carry off the increased quantity of sewage. This is a factor they say that will have to be taken seriously into consideration when additional water is brought into the City from the Tansa Lake.

It is also highly desirable that all water brought into the City by different trunk mains from different lakes should be in the first instance discharged into what the late Mr. Santo Crimp called "balancing" or distributing reservoirs and thus supplied to the City, because the full discharging capacity of a supply main can be obtained in that way only. We have in the City of Bombay already two balancing reservoirs—Malabar Hill and Bhandarwada—and, as pointed out by Mr. Crimp, for the northern and a portion of the central division of the City another balancing reservoir somewhere on the hills on the east of Old Government House, Parol, where now the Research Loboratory is located, should be soon provided.

THE STANDARD OF WATER PURITY FOR INDIA.

By Dr. N. N. KATRAK.

Pure or purified water may be defined as water which is safe for drinking and dietetic purposes. Water as H_2O being unknown in nature in a pure state, always contains various extraneous matters, both inorganic as well as organic and organized. These extraneous matters, in many cases, improve the quality of water, in some

cases they render it unpalatable, while in other cases, they make it positively harmful. These harmful substances, which may be divided into two classes—inorganic and organic—produce typical injurious effects on the human system. It is the latter class, *viz.*, the organic or rather organized matters, which will be treated of in this paper. It is now well known that various pathogenic organisms now and again gain entrance into potable waters. There is a long list of such organisms given in various books; for practical purposes, however, it may be said that Bacillus Typhosus and its allies Bacillus Coli Communis, Bacillus Enteritidis Sporogenes, Strepto-Coccus and Spirillum Choleric Asiaticus are the principal pathogenic germs with which sanitarians have to contend. In Europe and America attempts have been made, and with evident success, to prevent these pathogenic germs reaching the human system through the medium of potable waters: and various measures have been more or less successfully employed to achieve that end. The question which it is proposed to deal with in this paper is whether similar measures can be employed with like success in India. In Europe and America, with a view to determine whether a particular water is pure or not, *i.e.*, whether it is safe for drinking and dietetic purposes, a standard has been fixed for inorganic as well as for organic matters. In this paper, however, the latter part alone will be dealt with, as being the more important. The standard fixed for the latter is that, for a water to be regarded as pure, the effluent from each filter should not yield more than 100 microbes per cubic centimeter on gelatine plates. This standard has been fixed by Professor Koch of Berlin, to whom the world is indebted for many epoch-making discoveries of far-reaching consequences to humanity. Of late, a subsidiary standard has been suggested and acted upon to a certain extent. It is that excretal B. coli and Strepto-Cocci should be absent from 100 c. c. of waters of springs and deep wells, and from 10 c. c. of surface waters, *e.g.*, from rivers, shallow wells, upland surface waters, etc., if used for potable purposes; and that B. Enteritides Sporogenes should be absent from 1000 c. c. of waters of springs and deep wells and from 100 c. c. of waters from rivers, shallow wells, upland surface waters, &c., if used for potable purposes. Waters purified up to these standards have been found to practically prevent water-borne diseases being communicated to the consumers. This has been ascertained by noting the effects of such waters on the health and lives of a community. For this purpose, Enteric fever mortality has been adopted as an index of the success or otherwise of these standards of water purity and regular classes have been made of towns and cities according to the percentage of mortality from that disease. Thus cities with a death-rate from "Enteric" of not more than 10 per 100,000 population living are regarded as first class water purity towns; those above 10 and under 20 second class, and so on. This test has been applied not only to small towns with a population of a few thousands, but even to such leviathans as London, Paris, New York, Vienna, Berlin, &c. The question then arises whether similar standards and similar tests can be adopted for a vast continent like India with extremes of temperatures and with seasons and habits of the people different from those of Europe and America? Does Koch's standard of 100 microbes per c. c. and the subsidiary standard described above hold good in this country and can typhoid fever mortality be taken as an index of the success or otherwise of these standards? It may, however, be noted that up to within a few years the very existence of Enteric fever amongst the people of India was doubted. The sanitary authorities of many places have not yet separated typhoid from other fevers. There is, no doubt, however, that undoubted cases of Enteric are now met with or rather diagnosed. Moreover, with a better knowledge of bacteriology and greater facilities for bacteriological examinations, it has been found that many of those cases which were formerly regarded as those of Remittent fever are pathologically true Typhoid fever cases or cases of the Typhoid type, *viz.*, paratyphoid A. and paratyphoid B. It is possible that if this matter be more closely studied, it will be found that the majority of these Remittent fever cases are either true Typhoid cases or those of paratyphoid, leaving a few Malarial cases of a remittent type.

It need hardly be stated that cases of paratyphoid fever are due to organisms named Bac. paratyphoid A. and paratyphoid B., but the majority belong or are rather due to the latter organism; though the course and type of these cases are less virulent, still pathologically they are more or less similar to those of typhoid. They also give agglutination tests for their respective microbes. Now these Bacilli paratyphoid A. and B. belong to Coli-typhosus group, sub-group—Gärtner; B. typhosus being, broadly speaking, at one extremity, the most injurious of the series; B. Coli Communis, being at the other extremity of the series, least harmful (broadly speaking); and the Gärtner group, including B. paratyphoid being as it were midway. This raises the question whether it should not be the object in purifying waters in India to prevent the entrance of the organism of true typhoid as well as that of paratyphoid in the public water-supply. If so, fever cases require to be more carefully diagnosed before the typhoid and paratyphoid fever mortality is taken as an index of the success or otherwise of any standard of water purity.

From the above it will be seen that, so long as fever cases are not carefully differentiated and the nomenclature more clearly defined, so long will the test of the success or otherwise of any water purity standard adopted in India remain defective. In view of the above difficulties it would be worth while considering, if some test other than typhoid fever mortality cannot be adopted to gauge the success or otherwise of any standard of water purity that may be fixed for India. Cholera is also a water-borne disease. It is very prevalent in India, and its connection with water-supply is recognised even by the lay public. It is also a common experience that deaths from cholera in a place decrease as soon and so long as the water-supply is placed on a satisfactory basis. Taking Bombay as an instance, it is well known

that before 1865 cholera claimed a very large number of deaths in the City. Since the introduction into the City of Vehar Lake water and subsequently of other lake waters, deaths from cholera have been greatly reduced. Cannot deaths from cholera be taken as an index of the success or otherwise of the water purity standard that may be adopted in India? It need hardly be stated that close and exhaustive observations will have to be conducted whichever disease is adopted as a test of water purity standard. No doubt there will be many difficulties in this poor and sanitarily backward country to work out such a highly scientific and technical problem. But it is now high time that some definite course is fixed upon. At present, practically nothing has been done to determine whether Professor Koch's standard with the subsidiary standard detailed above is the proper standard for India. It is assumed that it is so. But beyond the high name of the discoverer of that standard, which is taken as a guarantee of its correctness, nothing more has been done in that direction.

Taking Bombay for illustration, it will be noted that in 1904-05* typhoid fever deaths in the city were 55 in number. These for a population of well-nigh a million work out to 5·5 per 100,000. This bare statement might place Bombay by the side of first class water purity towns in Europe and America. Now, water as supplied to the consumers in Bombay is known to nearly always contain much over 100 microbes per c.c. (the subsidiary standard being never worked). In view of the above fact, it is clear that either 55 deaths recorded as due to typhoid are too few, *i.e.*, many deaths which ought to have gone to swell the figure of 55 have been assigned to other diseases through faulty diagnosis, or the standard of 100 microbes per c.c. is too high for India. If, however, the Bombay mortality is a little more carefully examined, it will be found that there is another column with the heading "Fevers other than Malarial and Enteric," the deaths in this column being 2,091. It is safe to assume that a great majority (if not the whole) of these deaths is due to true Enteric or to paratyphoid fevers. If the above supposition be correct, then Koch's standard may prove to be proper for India or even too low, but unless and until fever cases are more carefully diagnosed and differentiated it will not be possible to conduct water-works in India on the same high state of efficiency as in Europe. It is possible in small places like military cantonments for careful observations to be made of the effects on the consumers of Koch's or some other standard of the purity of water; and though the experience of small places and small and peculiarly regulated communities may not be as useful as that of, and as applicable to, large towns and big communities with different and varied habits, still if these observations are collected and carefully organised useful data will be available to determine the proper standard of water purity for India. The question is one of great sanitary importance. The fever mortality in India is admitted to be appalling. How far potable water acts as a medium through which organisms producing fevers in India are carried to the human system it is not easy to determine under the present sanitary condition of India ; but it is possible that sufficient importance has not been given to this factor nor its dangers fully realized. It may be that a pure water-supply for the country may cause a considerable diminution in the fever mortality of India. What is meant to be conveyed by the above remark is that sufficient importance does not seem to have been given to impure water as being responsible for a substantial part of the fever mortality in India.

The question also is one of economic importance. If Koch's standard of 100 microbes per c.c. and the subsidiary standard mentioned above were found to be too high for India, then it would be possible to construct filters of lesser areas for a given quantity of water, which would mean so much money saved for other sanitary measures for Municipalities and local boards. If, however, it is found that Koch's standard is too low for India, then in the interests of the health and lives of millions of the inhabitants of the country increased expenditure will have to be incurred. Careful observations on this problem may perhaps also reveal that a standard of water purity which is good for Simla or Darjeeling may not be found suitable for Jacobabad, nor that of Bombay or Calcutta for Agra or Delhi. Whichever disease—cholera or typhoid fever—with its allies is taken as an index of the success or otherwise of a water purity standard, this question requires to be very carefully investigated and the results of various places carefully collected and compared. If this Congress were to prominently direct the attention of Government and various Municipalities and Local Boards, with a view to secure co-operation and mutual assistance and exchange of experiences, the object of this contribution will have been gained.

* Figures available for the last three years are as given below :—

	Deaths from		
——	Enteric.	Malaria.	Fevers other than Enteric and Malaria.
1904-05	55	270	2,091
1905-06	60	267	2,551
1906 07	134	190	4,558

A NEW METHOD OF DISINFECTION OF WELLS IN CHOLERA.

By K. T. MATTHEW, B.HY., D.P.H.,

Late Acting Health Officer, Madras Corporation.

Of all water-borne diseases Cholera and Typhoid claim pre-eminently the attention of Public Health Officers—nay, but for these, the water-supply would not have held the prominent place which it holds among the public health works of a town or district.

Although many of the large cities and towns in this country have their public water-supplies from approved sources and filtered, the well still forms the water-supply of the people in the rural districts and in many large towns. Even in towns with public water-supplies the well is still used by many, a few from caste prejudices, a fairly large number from want of confidence in the public supplies and a still larger number from sheer custom and blind faith in the good quality of the ancestral well.

The wells in cities and towns provided with public water-supplies have become real sources of danger, not only from their becoming excellent breeding grounds for mosquitoes but also from their occasionally being used when the public supply fails or becomes scanty as sometimes happens in Madras in hot weather. It is obvious that a well in constant use has its water in much better condition than an unused well, and, added to this, is the fact that an unused well is often, accidently or intentionally, the repository of all kinds of rubbish and filth. Little wonder, therefore, that in large towns in this country the full beneficial effects of public water-supplies are not evident, and, in times of epidemics of cholera, the well is often found to be the source of mischief. In Madras at any rate over and over again there have been unmistakeable evidences of the well becoming the starting point of an epidemic. The reports of the Health Officer on cholera outbreaks in the Madras City make this quite clear.

Even if the public water-supplies were much better both in quality and quantity than what they are at present, there would still be a fairly large section of people who would cling to their wells, if not for drinking purposes, at least for such domestic purposes as washing cooking utensils, drinking vessels, &c., unless strong measures were taken for the closure of every well in a place provided with a public water-supply. The enormous risk that follows from the use of contaminated well water for such domestic purposes is apparent when it is said that the natives of the country never dry their eating or drinking vessels before use. A *lota* used for drinking has its sides glistening with hundreds of drops of well water with which it was washed when the filtered pipe water is poured into it !! The practical corollary is that in dealing with a water-borne disease it is not only necessary to supervise the drinking water-supply but it is also equally necessary to look after every source from which water can possibly be derived for domestic purposes.

In the case of rural districts there is no near prospect of any other than the well supply being available. The well must remain, therefore, an important concern of all health officials in this country for a long time to come, and the disinfection of wells will continue to be an important part of the preventive measures adopted for combating cholera outbreaks in this country.

Permanganate of potash has long been reckoned among the chemical disinfectants, but, owing to its very feeble powers, it has seldom been used, except in cases where its non-poisonous nature was an advantage. In 1894 Mr. E. H. Hankin, Chemical Examiner and Bacteriologist to North-West Provinces, advocated the use of permanganate of potash for disinfection of wells in connection with cholera outbreaks. The effect of this substance according to him is "not so much in completely destroying the microbe but rather in removing some conditions necessary for maintaining its virulence or its quantity[1] and the permanganate may possibly render the water unfit to support the life of a cholera microbe. This, however, is only a probability and not an ascertained fact."[2]

Permanganate has been extensively used in Madras City during cholera outbreaks ; so largely has it been used that it is estimated that some tons of it have been spent during the last 10 years.

The impression left in my mind after such an extensive use of permanganate is its utter inefficiency as a disinfectant for wells, a view which is shared by the Health Officers past and present of this City.

Alum and quicklime reckoned among the disinfectants for wells are found in practice unsuitable for the purpose for one reason or another and it is very doubtful whether these substances have any antiseptic effect on the cholera vibrio.

"Choice of a disinfectant for disinfection of wells is by no means easy. The property that such a disinfectant ought to have is obvious. Before all things it must not be highly poisonous. This consideration excludes for instance corrosive sublimate. It should be readily procurable cheap and easy to apply. It should be without any action on brass vessels used by natives." [3]

I have during the last 3 epidemics of cholera in this City been experimenting with "acetic acid" for disinfection of wells. The "acetisation" of wells, as I conveniently term my process, is a very simple and, so far as I can see, a very efficient method of disinfecting wells. The whole process is extremely simple. Add enough glacial acetic acid to make the whole body

[1] Hankin on Cholera in Indian Cantonments, p. 11.
[2] Do. do. do. p. 49.
[3] Hankin on the Disinfection of Wells.—*Indian Medical Gazette*, November, 1894.

of the water in a well faintly acid. All that is required is a large ounce glass and blue litmus paper and glacial acetic acid. The process is based on the well-known scientific fact that the cholera microbe is readily killed by an acid and, even in faintly acid media, the growth of the organism is inhibited. The value of acid in the treatment of cholera has long been recognised—long before the organism itself was discovered by Koch in 1884, but the rationale of the treatment was not known until the organism was isolated and its behaviour towards acids was known. Acid sulphuric formed the basis of many a cholera specific and both hydrochloric and sulphuric acids were given in small quantities, added to drinking water as prophylactics against cholera. Carbonic acid gas in aerated waters exerts a destructive effect on the organism and hence the safety—so often spoken of—of aerated waters in times of epidemics. A well-known cholera specific is made up of acetic acid and spirits of nitrous ether. The reason for failure of the earlier experimental inoculation of cholera was the acid condition of the stomach of the inoculated animals, and, with the neutralisation of the acidity by sodium carbonate, a large proportion of the animals inoculated became infected with cholera.

It is said that cholera endemic in the valley of the Ganges never travels down stream. I know of a severe outbreak of cholera some time ago among the pilgrims to Sourimalai Temple in Travancore and large numbers of bodies of the dead from cholera were thrown into the Pampa river, apparently without any ill-effect to the thousands who used the water of this river, for drinking purposes, some 20 miles down the stream.

Hankin says that "his observations concerning the paucity of microbes in these Indian rivers led him to make the suggestion that cholera microbes probably die when placed in such rivers." (Hankin on Cholera in Indian Cantonments. p. 4, para. 1.)

The reason is that the water of all large flowing rivers is either neutral or very faintly acid and so faintly as not to be perceptible to the ordinary blue litmus paper; this however is not the case when large quantities of sewage are let into such rivers or when the intake is within the tidal flow of the sea. The sewage of the sea water alters the reaction then to faintly alkaline, a condition distinctly favourable to the maintenance of vitality if not to the growth of the cholera organism. Small rivers which periodically dry up, canals, &c., owing to their more or less stagnant condition, form fertile breeding grounds for the organism when once infected. The antiseptic effect exerted by the water of large flowing rivers referred to by Hankin is due to the high aeration of the water.

The well, on the other hand, is a stagnant body of water subject to much larger pollution than any large river but yet without its self-purifying powers ; besides the well is very seriously liable to pollution from the surface in a large variety of ways. In the immediate vicinity of the well is almost always situated the bathing and washing place. All kinds of vessels are let into the well for drawing water and, where the well is common to many houses, each house uses its own *lota* and rope for taking water from the well. The enormity of danger of pollution under such conditions is evident.

The "acetisation" of wells tried by me during the last 3 years has been attended with encouraging results. Two large streets or isolated blocks in a badly infected locality were taken and all the wells in one were treated with acetic acid, and in the second with permanganate of potash, with the result that the incidence of attacks, which continued to be about the same till the time of the experiment, changed markedly in from 24 to 48 hours. The number of attacks was noticeably less in the former case than in the latter. But the most interesting point was that the benefit of the permanganate treatment disappeared with the decolourisation of the water ; but in the case of the acetic acid the effect was not only marked but continued for a considerable period. Besides the water of a well treated with acetic acid being unchanged to naked eye appearances, there is really no interruption in the use of the water for domestic purposes and there is no hardship on the people at all so far as their water-supply is concerned. The position is different with regard to permanganate. The deep colourisation of the water is an effective bar to its being used for any purpose, and in fact it is this actual prevention of use that is of value in Hankinisation, as is evidenced by the fact that with the decolourisation also the effect of disinfection by permanganate disappears. If Hankinisation really had anything more than a mechanical effect, the decolourisation should not have made any change for the worse, nay, the decolourisation being the result of oxidisation it should have shown its beneficial effect with the diminution or disappearance of the pabulum which provides for the growth of the vibrios. But cholera vibrios can live and multiply, although to a limited extent, in good potable or sterile water, and therefore even the complete removal of the oxidisable organic impurities present in the water cannot in itself be a guarantee of the removal or destruction of the specific organism in the water. It is clear, therefore, that the permanganate solution has no specific effect on the infected well and the only beneficial effect is the mechanical one resulting from the deep coloration of the water.

The "acetisation" has, in my opinion, a specific effect on the cholera organism in an infected water-supply. It destroys the specific organism. The advantages claimed for the process are—it is effective, simple, cheap and absolutely incapable of doing any harm even in untrained hands. It does not affect the physical character of the water—a matter of considerable importance in dealing with an epidemic in this country. There is besides the question of great hardship imposed upon a village or rural district by the wholesale Hankinisation of the wells depriving the public of the use of the water for some hours or days. The irritation caused by such a procedure results in the concealment of cases and obstruction to the sanitary measures for the prevention of the spread of the epidemic. Then the deep coloration engenders in the mind of the ignorant a suspicion as to the object and effect of the substance added. Although hap-

pily this suspicion has practically died out in most of the larger cities in this country, in the rural districts it is not the case. Further, acetic acid is a substance, the qualities of which are well known to the natives in this country. " Kadi" (country vinegar made from toddy—palm juice) is used in every house for making curry and pickle and it is looked upon as a valuable stomachic. To convince the people of the nature of the stuff used, for acetisation of wells, one need only put a few drops of the acetic acid in a small pot of water and ask them to smell or taste it. In fact the experiment made in Madras during the last 3 years justifies the assertion that Indians are likely to raise little objection to " acetisation" of wells.

These notes are written to draw the attention of Public Health Officers in this country, some of whom have better opportunities and time for making further experiment on the merits of the process and who, if they find it of value, may work out the details to ensure success to a subject of considerable importance in dealing with that most deadly and dreaded of all epidemic diseases, Cholera, which year after year exacts such heavy tolls on the population of this country.

ON THE CHEMICAL TREATMENT OF WATER TO RENDER IT FREE OF WATER-BEARING DISEASE BACTERIA.

By Capt. V. B. NESFIELD, F.R.C.S. (England), I.M.S.,

Civil Surgeon, Gauhati, Assam.

There are 4 chemicals which may be employed to render water incapable of producing water-borne disease.

Namely:—Mercury, Chlorine, Iodine, and Permanganate of Potash.

The germicidal value of these substances, for the B. Coli, as it occurs naturally in water, I find to be as follows:—

(100 B. Coli per C. C., Temp. about 85°F.)

1.	Perchloride of Mercury ...	1 in 5.000,000 / 1 hour's contact
2.	Chlorine	1 in 760.000 / 10 minutes' contact
3.	Iodine	1 in 760 000 / 10 minutes' contact
4.	Permanganate of Potash ...	1 in 760,000 / 1 hour's contact

As these values are somewhat higher than recorded in the text-books, it is necessary to state the method of experimentation, which is, I think, an improvement on the existing methods.

The Method Described.

Liqueur glasses are placed in a row. A 1 in 10,000 or other suitable dilution of the germicide under trial is prepared.

A beaker of clear natural water, previously found to contain B. Coli, is placed on the table.

9 c. c. of this water are placed in the first liqueur glass.

Into the next, 9·1 c.c., the 3rd 9·2 c.c., the 4th 9·3 c.c. and so on up to 9·9 c.c. in the 10th glass.

To the first liqueur glass is then added 1 c.c. of the germicidal fluid, to the 2nd ·9 c.c, to the 3rd ·8 c.c., to the 4th ·7 c.c. and so on to ·1 c.c. in the 10th glass; each addition being timed by a 1 minute interval, and thus on completing the 10th addition, 9 minutes will have elapsed. By the termination of the 10th minute 5 c.c. of fluid from liqueur glass No. 1 are placed in a Bile-Salt-peptone-glucose tube.

The same quantity is placed after each succeeding minute, and from each succeeding liqueur glass, into separate tubes.

These are incubated, and the results noted after the lapse of 1, 2, 3, and 4 days.

To the tube which shows no growth with the highest dilution, two loop-fuls of the original bacterium containing water are added; a growth showing that the germicide added with the 5 c.c. sample has produced no inhibiting action.

With the above example, one obtains dilutions of:—

1 in 100,000	... ...	$(10,000 \times \frac{10}{1})$
1 in 111,111	... ...	$(10,000 \times \frac{10}{\cdot 9})$
1 in 125,000	... ...	$(10,000 \times \frac{10}{\cdot 8})$
1 in 144,000	... ..	$(10,000 \times \frac{10}{\cdot 7})$
1 in 1,000,000	... ...	$(10,000 \times \frac{10}{\cdot 1})$

For absolute and accurate results, required for comparative values, a constant temperature, and a bacterial fluid consisting of distilled water containing a fixed bacterial population derived from a 24 hours' old agar slope (prepared according to a fixed formula) of a fixed strain of B. Coli, is necessary.

The temperature is easily regulated, by standing the liqueur glasses in a tray of water.[1]

This method eliminates the factor of chemical interaction between the germicide and the bacterial fluid; which, in the Rideal-Walker method, plays such an

[1] I suggest 100,000 B. Coli per c.c. and a temperature of 98·4° F with a time limit of 10 minutes.

important role, especially with those germicides such as $K\ MNO_4$ Cl. and I, which react with peptone.

The Rideal-Walker method gives these substances, and incorrectly low value.

. . . .

But, although the above is the germicidal value of $Hg\ Cl_2$, I, Cl, and $K\ MNO_4$, in an average water, in practice, one must employ a lower dilution, that is, a greater number of grains per gallon, for organic matter absorbs and nullifies Cl, I, and $K\ MNO_4$, while, $Hg\ Cl_2$, is to some extent affected by inorganic matter.

Hence, so as to ensure absolute safety for an unknown water, I recommend the following dilutions :—

Perchloride of mercury.. 1 in 1,000,000 (1/14 grain per gallon) in 1 hour.

Permanganate of Potash... 1 in 70,000 (1 grain per gallon) in 1 hour.

Iodine ... ... 1 in 70,000 (1 grain per gallon) in 10 minutes.

Chlorine ... ... 1 in 70,000 (1 grain per gallon) in 10 minutes.

NOTE.—Should a water-supply be in constant use, a very little experimentation will show if $\frac{1}{2}$ or $\frac{1}{4}$ of these amounts cannot be used with safety.

But, whereas the chemical composition of a water-supply exerts an influence on the lethal effect of a chemical germicide, suspended particles play a far more important part, as bacteria, ensconced inside these particles, are protected from the action of the chemical.

Hence, to chemically render a muddy water incapable of conveying water-borne disease, it is necessary first to strain it.

I find that one layer of a blanket, or one stout layer of flannel, or sedimentation alone or with alumin, is sufficient for this purpose. As the minute particles of mud which remain do not offer a sufficient protection to any possible ensconced bacteria, when the germicides mentioned are used in the recommended strength, and time contacts.

. . . .

II

Having killed the bacteria, it is now necessary to render the water potable.

With perchloride of mercury nothing further need be done, as there is no taste, and an average man, drinking 4 pints in the day, would only consume 1/28 grain of $Hg\ Cl_2$ per day, which at any rate for some weeks produces no pathological result.

In the case of Permanganate of Potash, I know of no good way to improve the appearance of the water; Hyposulphite of Soda changes the pink tint to a pale yellow, which is sometimes useful in the case of Natives of India.

Both Chlorine and Iodine are readily removed by Sulphite or Hyposulphite of Soda.

III

The last point for consideration is the form in which these substances shall be put up, so as to be convenient in practice.

Perchloride of Mercury and Potassium Permanganate with $HgCl_2$ and $K\ MNO_4$, a simple calculation gives the quantity necessary, 1/14 grain per gallon of the former, and 1 grain per gallon of the latter. Contact 1 hour.

To prevent accidents with perchloride of mercury, a good plan is to use a mixture of 15 parts of this salt with 1 part of methylene blue. 1/14 grain per gallon of this mixture gives 1 in 1,000,000 HgCl (nearly) and a faint blue tint.

Chlorine.

Chlorine may be employed in one of two forms.

A—As the Hypochlorite of Lime, which because it readily decomposes in India, even in a stoppered bottle, must be sealed in glass tubes.

Capsules containing 50 grains are very convenient, 1 gallon of water requiring 1 grain of Hypochlorite of Lime, with a contact of 10 minutes.

B.—As the liquid gas, which is extremely convenient, and which I have largely used.

The gas is stored in quantities of 5, 10, and 20 lbs. in steel cylinders.

The nozzle of each cylinder contains a five thermometer tube, the length of which is such that the friction entailed on the issuing gas only permits one grain of chlorine to escape per second.

The gas is conducted by a narrow rubber canvas-covered tube to a diffuser, which consists of two discs of gas carbon, opposed to each other by a brass clamp, while one disc is provided with a nipple of China inserted in the circumference of the disc.

The gas passes *via* the nipple, between the faces of the carbon discs, and escapes round the margins ; the smallness of the bubbles being regulated by the pressure of the brass clamp.

The brass is not acted upon. The diffuser is placed in a tank of water, which is stirred, and the gas is then turned on.

As soon as it begins to escape, one second is counted for each gallon of water to be treated ; the diffuser is then removed, and the water is allowed to stand for 10 minutes. Then, 1 grain of Hypo-sulphite of Soda is added for each gallon to bring about dechlorination.

Iodine.

Iodine is best employed as a fresh solution prepared by the interaction of an organic acid on Potassium Iodide and Iodate, (compounded according to the formula $5\ K\ I + K\ IO_3$) in the presence of water.

The water being deiodized by Hypo-sulphite of Soda.

There is now a vast mass of evidence to prove the efficacy of this last process, used, under the most trying and adverse circumstances, both in peace and war; indeed, the value of Iodine, in this respect, is past the stage of controversy, having proved of good value in Sikkim during the Tibet expedition, during the Amir of Afghanistan's visit to Agra, during various military and plague camps, and during the last famine in the United Provinces. It was used, also, during the late Mohmund expedition.

. . . .

The right of my authorship to this process has been questioned. I can only say, that I began working on the chemical purification of water in 1900, and decided on chlorine as being the most suitable substance. In 1903, I published an article in the Journal of Public Health, describing the use of the liquid gas, and also Hypo-chlorite of lime, using sodium sulphite as a dechlorinator. While working with chlorine, the difficulty of overcoming the non-stability of bleaching-powder, led me to use Iodine, which, though not physiologically so good as chlorine, yet shows the very distinct chemical advantage, of possessing a stable Iodate, which, in the presence of an Iodide, and a weak acid, sets free Iodine.

Nothing, indeed, could be more natural than that Iodine should call for experimentation, for the purification of water, as it is one of the standard disinfectants used in Hospital practice. (Dr. i of Tinct. Iodi per pint of water = 1 in 6,400.)

And nothing is more natural than when wishing to apply it practically, that one should employ the stable and solid compound of Iodide and Iodate of Potash, produced by neutralising Iodine with Caustic Potash, and Citric or Tartaric acid to reliberate Iodine, and sulphite or Hypo-Sulphite of Soda, when wishing to de-Iodize.

And, as these three substances are incompatable, to dispense them as separate powders or tablets is the only possible plan. It is in this form that the process is now exhibited for use.

Vaillard has also introduced this system in the French Army, in the form of red, white, and blue tablets (the quantity of Iodine used is 3 times what I recommended), but I knew nothing of his work till after I had put to practical use and published in the I. M. G. and Journal of Preventive Medicine (1905) my work on the subject. This was more than two years after I had completed the details of the process. Moreover, with my sanction, English, Indian, and South African patents were granted to a chemical firm. Had Vaillard's work been known, the patents would not have been permitted.

The late famine in the U. P. proved the efficacy of Permanganate of Potash (and also Iodine) in checking cholera; so much so, that it seems superfluous to draw attention to this drug (Permanganate of Potash). I would not do so unless it were that its germicidal value is invariably placed far too low.

This is due to experimentation by the drop or other method, where a comparatively large quantity of Peptone Broth is brought into contact with dilute solutions of $K\,MNO_4$, with the result that a comparatively large portion of the $K\,MNO_4$ is absorbed.

This is readily demonstrated by the following experiment.

To 300 c.c. of 1 in 100,000 $K\,MNO_4$ solution, add 300 drops (μ) of Peptone Broth. After a few moments, nearly all the colour is discharged, so that, one is no longer dealing with a 1 in 100,000 solution.

The same applies to Iodine and Chlorine. It is highly unscientific and profitless to deduce germicidal values for substances which act on Peptone and organic matter by such experimental methods, and, on these results, to discredit their value when applied in practice.

Addendum.

For the Disinfection of Wells in use daily—1. Either 1/10 grain of Permanganate of Potash per gallon may be added, which should produce a faint pink tint. If there is no tint, a little more Permanganate should be added. *Cost* 8,000 gallons per penny. 2. Or, if the colour be objected to, 1/70 grain of Perchloride of Mercury may be used for each gallon (1 in 5,000,000). *Cost* 12,500 gallons per penny. This water will be safe to drink in 1 hour's time.

For the disinfection of large open tanks or pools. Water foul.—Hypochlorite of lime is perhaps the most convenient, ½ grain being used for each gallon, *i.e.*, 1 lb. for 3,500 gallons. The Hypo-chlorite must be active; this is ensured by hermitically sealing the dry and fresh powder in glass capsules,[1] holding 1 to 10 pounds of this substance.

A sample of the water should give a faint yellow tint on adding a crystal of Potassium Iodide.

The water gradually dechlorinates by exposure to sun and air.

For Small Water Works, e.g., for Factories.—The liquid gas is the most convenient, ¼ grain per gallon being in most cases sufficient. The chlorination and dechlorination being carried out in the same tank.

Cost of liquid chlorine 2/6 *d* per lb. at ¼ gr. = 933 gallons per penny exclusive of the Hypo-sulphite.

For Military purposes, Barracks, Soda-water Factories, Segregation and Famine Camps, and Private use, the Iodine process is the simplest, neither filtration or boiling being comparable in effectiveness (unless very closely supervised) or practicability.

By this means cool and tasteless water, free from water-borne disease organisms, can be prepared in 10 minutes.

The only appliance necessary is a water vessel or vessels in which to carry out the purification.

When the water is particularly bad, it should first be faintly pinked with permanganate, and then treated with the Iodine. The subsequent de-Iodization converts the faint pink to a pale yellow colour.

DISCUSSION.

Mr. G. R. Williams, Sanitary Engineer, Bengal, in opening the discussion on the subject of water-supplies, said that he would like to say in the first instance that as he had not been present in the morning during the greater part of the time, he had not had the advantange of hearing the two first papers on the list read. He therefore confined his remarks to a criticism of the two papers on water-supplies submitted by Dr. Dadachanji.

He further prefaced those remarks by saying that he did not wish to express immature and hasty opinions on a problem of such great importance as the improvement of water-supplies in India with which he would be closely connected in future and which in India took a somewhat unfamiliar form.

As a matter of fact these two papers avoided any question of general policy and were really a somewhat disconnected series of suggestions and statements, many of which were

[1] Experimenting in March 1904 at Agra, I found that 1 lb. bottles of Hypochlorite of lime sealed with a cork and waxed in the ordinary way, evolved Cl, although the cork was in no way loosened. The substance which remained was $Ca\ Co_3$. If Co_2 be absolutely excluded from coming into contact with $Ca\,(Ocl_2)\,Cacl_2$ by hermetically sealing in glass, the high Indian temperatures do not produce disassociation of the Cl, nor did I find the hypochlorite to change into chlorate.

open to criticism and some of which he thought the author would find it difficult to substantiate.

He would endeavour so far as time permitted to go through a few of details and make a few remarks where he thought it was necessary.

The first practical suggestion made in the first paper was that Hydraulic Laboratories should be established, but he supposed the object the author had in view was that Sanitary Water Surveys should be instituted and he could only say that although he thought it likely that such Surveys would be valuable, at the same time he did not think that they would be much good if confined to such narrow limits as suggested.

Sanitary water surveys had been instituted in America and the scope of their work had included the quality and quantity of sub-soil waters and of the surface waters over whole water sheds, and they had proved of considerable value. When he came to the reason given for some work of this kind he found a remarkable statement "that the deaths of children under five years of age, after excluding deaths from diarrhœa, was inversely proportional to the quantity of water present year by year in the ground, that is when there was a large volume of water in the ground the death-rate declined, and with a small quantity of water the death-rate was considerably augmented." He wished to know what proof the author had for that statement. Because he was bound to say that he had not heard of any and he would be glad if the author had any proofs or if he could give any explanation of this extraordinary phenomena.

Coming next to the measures the author recommended for the protection of water-supplies, he was quite convinced that no water-supply from a river flowing through a thickly populated country was safe unless some form of filtration were adopted.

He passed over next to the other suggested precautions, some of which were fairly obvious ones, but he wished to refer to the author's suggestion as to the water-supply in artificial lakes.

The suggestion of continual dredging was a highly objectionable one. If reservoirs were properly constructed in the first instance no such work should be required. In constructing a large reservoir all the soil and vegetation should be stripped from the site before the reservoir was filled. Any shallow places should be filled in. If this were done he did not think that under ordinary circumstances there should be any necessity to do the work suggested by the author.

Further on there were several matters which required some elucidation. The author appeared to imagine that there were two different layers of bacteria in the earth, the top layer being beneficent and the lower pathogenic. He was bound to confess that this was news to him and he wished to have further information on the subject.

The next point was with regard to the inclined surface of underground water. What the author should have said was that all underground water was constantly in motion and that consequently the surface was bound to incline in order that it might have sufficient head to force its way through the intervening rocks.

The statement that cholera in London in 1854 was due to the upturning of the earth in which the plague-striken victims of 1665 had been buried was distinctly interesting. While he had an idea that he had seen that statement before he said that he had never taken it seriously. It would be a curious biological fact that plague bacilli should after two hundred years' burial be turned into cholera germs! To him this appeared to be somewhat improbable. With regard to lead poisoning he had known of cases in soft peaty waters from uplands and it was possible that in India waters from some wells might have this power. One part of lead per million was not a safe standard, as half as much might have a serious effect on public health.

With regard to the second paper he did not think it was right to quote Sir Alexander Binnie as saying that owing to the pollution of the water-supply of London "there would arise among the teaming millions of London an epidemic such as that which visited Hamburg a few years ago," without also stating that two Royal Commissions had expressed a contrary opinion and did not believe that such an epidemic was likely to occur.

With regard to estimating whether organic matter in water was of animal or vegetable origin the more common method was to take the quantity of oxygen absorbed and the ratio of albuminoid ammonia to free ammonia, and if both these were high the contamination was probably due to vegetable matter.

He could give the results of four analyses of waters in East Africa all highly contaminated by vegetable matter as examples, as the figures were interesting and showed the features he had mentioned.

Parts per 100,000.

	Ammonia. Free.	Ammonia. Alb.	Oxygen (3 hours.)	Chlorine.	Nitrates and Nitrites.
Naivasha Lake	·015	·0425	·416	1·5	Marked trace.
Newroba River	·0)1	·0190	·300	·8	Trace.
Njoro „	·003	·0130	·290	·8	Marked trace.
Victoria Nyanza Lake	·0025	·0412	·194	·7	Trace.

With regard to the author's remarks about covers over filters he wished to mention that the object of covering filters in Europe was to prevent freezing and there was no necessity for covering them for that purpose in India.

At Zurich it was found that covering filters increased the length of time during which they could be worked by ½ as much again, the covers having the effect of preventing vegetable growths in the filter. He disagreed as to the chlorine test being useless; when natural sources of chlorine were eliminated it was as useful a test for sewage contamination as any. He did not think that the author had quite made it clear in his paper what the object of chemical analysis was. It was useful as an indication of the probable presence or absence of pathogenic organisms. It was not he thought in itself a conclusive test as to whether water was pure or not, but was useful as corroborative evidence. Bacterial examination was undoubtedly by far the most valuable means of ascertaining the purity of water.

In concluding he took the opportunity of congratulating the author for the interesting paper he had prepared, which had lent itself to discussion in an admirable manner.

Dr. A. D. Mody, in referring to Dr. Katrak's paper, said that he agreed with Dr. Katrak that the deaths registered as due to fevers in the mortality tables of Bombay were mostly or to a great extent due to fevers of a typhoid type, as for example paratyphoid and enteric, and he went further and stated that many of the deaths registered as those of malaria might also be due to fever of typhoid type. He had all along been of opinion that the influence of impure water played a great part in the cause of fevers in Bombay and that this influence had been underestimated. To him it appeared inexplicable that the Indians could be so immune to typhoid fever and that Europeans who lived in comparatively more sanitary localities as regards diet and drinking water should suffer in such large proportion from typhoid fever. He believed that Indians were equally susceptible to the typhoid bacilli but that the symptoms were more or less modified. It was very desirable that the drinking water supplied to a city like Bombay should be so filtered and of such a standard of purity as that recommended by Dr. Katrak in his paper. In Bombay the whole supply was not filtered with the result that the people got filtered and unfiltered water for potable purposes, hence till the time when the city was in a position to get the whole supply filtered efficiently it was sheer waste to throw away filtered water for watering the roads and flushing the sewers, &c. It was imperative to supply filtered water separately from unfiltered water. He was assured that such a procedure was quite practicable in Bombay. Filtered and unfiltered water could be supplied at different hours. This measure was suggested to the Munioipal Executive by the speaker while he was

a Corporator. Since then it had been advocated from time to time but nothing had been done in that direction. They talked about the extensive spread of malaria and other fevers in Bombay, but nothing was done to ensure an absolutely safe supply of water to the public for potable purposes.

Dr. Pearse, Health Officer of Calcutta, in reference to Dr. Thresh's paper on purification of water supplies, said he considered the author had somewhat disregarded the value of sedimentation and storage before filtration and distribution. Dr. Houston's recent experiments, as well as laboratory researches, clearly showed the value of storage in the reduction of the number of bacteria. In Calcutta there were four large sedimentation tanks in which the river water after treatment with aluminno-ferric was allowed to settle and remain for 48 hours or over before being passed into the filters. Referring to Dr. Katrak's paper Dr. Pearse said he could not accept the suggestion of the author to take the amount of cholera or typhoid mortality as a test for the purity of the water supply for two reasons, first that the mortality statistics of India were so unreliable that it would be impossible to base a standard on them, and secondly that the two diseases varied in amount in different places from other causes than the purity or otherwise of the water supply.

Referring to Lieut.-Colonel Crimmin's paper on the methods of storage of drinking water on boardships Dr. Pearse said he considered the matter of such great importance, and the conditions under which drinking water was kept on boardships were so unsatisfactory, that he would with the permission of the members of that section move a resolution embodying the views of those present and urging upon the responsible authorities to take steps to safeguard the supply.

"That this Public Health Section of the Bombay Medical Congress of 19 9 is of opinion that the supply of drinking water on boardships is insufficiently protected from contamination and would urge on the Board of Trade that the shipping companies of the British Empire should be required to store their supplies of drinking water under adequate sanitary conditions."

Dr. K. E. Dadachanji seconded the resolution and the subject was put down for discussion at the second day's sitting.

Dr. A. G. Newell (Madras) remarked that Dr. Katrak referred to Koch's standard of water purity and a subsidiary standard and the index of the success or otherwise of the standard was based on the enteric mortality. It seemed to him that such an index would be highly dangerous since they knew (1) that the detection of paratyphoid cases was not easy; (2) that typhoid patients during the first week of the disease could infect by contact. Conradi had found that out of 85 cases no fewer than 58 per cent. contracted the disease by contact with certainty from patients during the first week of the disease ; (3) that chronic bacillus carriers could also infect without the medium of water ; and (4) that water-borne typhoid was a variety now-a-days. Evidence of the infrequency of water-borne typhoid was furnished by Dr. Seaton in his report on the prevalance of the disease in the County of Surrey (England), in which he pointed out that out of 2,093 cases occurring during twelve years it was doubtful whether even 10% of the cases could be attributed to water. Bangalore was the only example in India during 1907 (and 1908 so far as he knew) in which water was the cause of the outbreak. Outbreaks attributed to milk seemed to be on the increase. Lately it was shown by Dr. Houston's experiments that it was excessively difficult to detect even one typhoid bacillus from raw river water from the Thames. Recent discoveries went to show that the right method of preventing typhoid was the detection of those who harboured the disease with a view to render them innocuous. Kirchner had published a full account of operations taken on these lines during the last four years at a cost of £10,000 per annum in a number of districts in Germany, and, in spite of the difficulties connected with the detection of cases, he showed that a substantial decrease in the mortality from enteric occurred. In this connection it should be added that in India the Standing Committee on enteric had taken up the matter with energy and their recommendations on the point were at present being worked upon. Since both enteric and cholera might be spread by means other than water, it would give rise to faulty conclusions and it would not be safe to take either of these diseases as the index of any standard of water purity. He was in favour of keeping to Koch's standard.

The water pollution by grave-yards was a point that deserved much more attention than was given to it. It was to be hoped that cremation would be more practised and in this way pollution of water supplies from this cause would be prevented. One surface well might infect another surface well through the medium of a stream. Last year cholera broke out from a depression in the ground near the bank of a stream. There was no doubt that the surface of the ground around was polluted fœcally and that this so called well received the surface washings. The overflow of water from this went into the stream and fifty yards further down on the other side of the bank was a depression of the ground into which some of the water of the stream flowed back. The first place was discarded as a source and when the coolies resorted to the second place the cases still continued. The speaker had both places disinfected with potash permanganate and closed. The cases ceased at once to crop up. An elephant was once shot and buried a short distance from a well and there was a slope from the place of burial to the well. He advised the well to be completely closed up. Regarding purification of water by copper sulphate, Dr. Dadachanji was evidently not aware that the Massachusets State Board of Health would not sanction its use and that there was evidence that it was useless except in such quantities as would be harmful, and Moore and Kallarman's experiments had been subjected to very adverse criticism and were pointed out by Drs. Clark and Gage to be conducted on a very small scale.

Professor Norman Rudolf, M. S. F. S. C., Dept. of Applied Chemistry, Indian Institute of Science, Bangalore, said that he was extremely interested in Dr. Katrak's paper inasmuch as he had attempted to draw up a standard of purity for potable water, while he (the speaker) was engaged in water analysis work for Municipalities and District Boards in Bengal. In those days—some twenty years ago—the science of bacteriology had not attained its present importance as regarded water-borne diseases, and sanitarians had to rely mainly on chemical analysis. He had thought the subject of sufficient interest to induce him to read a paper before the Indian Medical Congress at Calcutta. Dr. Katrak's represented a great advance on his (the speaker's) suggestions as he had included the recent advances made in the science of bacteriology.

Dr. Jehangir J. Cursetjee believed he was correct when he understood Mr. Williams to say that he was not aware that infant mortality was in proportion to the level of the sub-soil water. They in Bombay could vouch for this statement. He thought it was Mr. Santo Crimp, and before him Mr. Baldwin Latham, who pointed out the fact that mortality from typhoid was greatly affected by the amount of waste or sub-soil water. That statement was borne out in subsequent years and from the tables published it would be seen as was pointed out by Dr. Dadachanji that the numbers of deaths had increased up to recent date and that the mortality had been due to the high level of sub-soil water. Turning to tanks Mr. Williams thought that there was no need for periodical cleaning of vegetable growth. They knew the source from which the people of this country took their drinking water, therefore the best course was to fill up the tanks. The next best course was to clean the tanks so as to prevent the tank growth. In Bombay all the tanks had vegetable growths and the Tansa and Vehar lakes were also similarly affected.

Coming to the level of underground water it was found to be inclined and the current was inclined in the water itself. He considered that the water came down the incline underground and therefore believed Dr. Dadachanji was right.

Regarding chemical water analysis he believed in bacteriolo-

gical examination and not microscopic. The determination of chlorine and free ammonia was not quite sufficient.

Coming to the paper of Dr. Katrak, and the remarks of Drs. Pearse and Newell thereon, he thought it would be difficult to fix typhoid as a standard on which Dr. Katrak based his water purity. It was a known fact that scarcely any cases of typhoid were recorded in the 70's and 80's so they could not take typhoid as a serious basis. Stray diagnosis was not a good ground work for a basis.

In Germany and other countries if a case occurred it was followed up from point to point in a manner that was not done in India, so that it would be unsafe on doubtful data to accept typhoid as a standard of water purity. The suggestion was not illogical, but as far as matters went in India the authorities were not likely to accept typhoid as a standard of water purity. Typhoid lurks in the system and recent investigations had proved that in large numbers of cases the typhoid bacilli got into the system and remained undetected. Recent investigations had been carried out by Government in cantonment hospitals when it was found that the soldier nurses had carried the germs to the barracks and spread the infection. And it was found to be necessary to examine all those soldier nurses and see whether their systems were quite clear of the infection before allowing them to mix with their comrades again.

There were certain other points he would have liked to touch upon, but time did not permit.

Dr. Dadachanji in replying to the criticisms said he was glad that Mr. Williams had passed remarks on his paper showing at the same time his knowledge as a Sanitary Engineer. The need for the establishment of a hydraulic laboratory and the relation of the death rate of children to the level of the underground water had been proved by various authorities, and it was a matter of great surprise to the speaker that Mr. Williams' attention had not been drawn to this. Mr. Williams wanted to know how there could be vegetation in artificial lakes if before being completed all vegetable growth were denuded. In reply to this he stated that Mr. Williams had no experience of Bombay and India. In the case of the Vehar and Tansa Lakes the problem the Municipality had to solve was how to get rid of the abundance of vegetable matter formed after the lakes were made on a clean soil. As regards the existence of bacteria in the first four feet of the superficial layer of the soil it was a recognised fact. Dr. Poore was the author who called this layer of soil the "living earth." As regards the inclined surface existing in underground water, that movements could not take place without this had been proved by Mr. Baldwin Latham the great Sanitary Engineer, before the Board of Sanitary Engineers. He gave instances of such cases proved by the lithia test notably the case of an outbreak of typhoid from Lausen in Switzerland, where the morbific matter was carried from one valley to another through a rising intervening ground. As to lead poisoning it was a fact that many Indian wells had acid water. At Chimbur, which was in the neighbourhood of Bombay, there were many wells which contained acid waters. With regard to the determination of chlorine in water, it was proved at the last Calcutta Medical Congress that the determination of chlorine was useless. He feared Mr. Williams had not studied up-to-date literature on this subject, otherwise how could he have lost sight of Sir Alexander Binnie's lecture on the subject? He was very thankful to Mr. Williams for his congratulation on his paper and in conclusion remarked that the use of sulphate of copper for water purification purposes had been tried in Bombay and had failed but the impression still remained in his mind that the experiment had not been carried out in the manner in which it should have been done.

Dr. Katrak then replied to the discussions on his paper. Before he proceeded to reply to the remarks made by various speakers, he desired, with the permission of the President of the Section, to make a few preliminary remarks adverting to Mechanical Filters. He admitted that the ordinary slow sand filters had been proved to be very efficient as filtering agents, but unfortunately they were very costly and beyond the means of various poor Municipal and Local Bodies. Hence Mechanical Filters which were cheap had been used in some places with considerable success, because they had been proved to produce a filtrate which was found to be free from chemical and organic impurities. In working this, a precipitant had to be used which was generally sulphate of alumina which combined with lime present in or added to the water and formed sulphate of lime and hydrate of alumina, both of which being insoluble were precipitated carrying with them all the solid particles including microbes. As the work of entangling and precipitating microbes and other solid particles was done by these chemicals, water was passed through sand at a considerably higher rate than in the ordinary sand filters. These filters were largely worked in America and to some extent in Europe and also in tropical places like Cairo in Egypt and Betmangala in India with marked success. He hoped that those poor Municipalities and Local Bodies who could not afford the cost of ordinary sand filters might go in for them instead of waiting for the ordinary sand filters.

Coming to the use of hypochlorites for water purification, the speaker said that when sea-water was electrolysed chloride of magnesium contained therein was converted into hypochlorite of magnesium and other indeterminate bodies. This process, which was called the Hermite Process, was advocated for sewage purification and a plant for producing electrolysed sea-water was ordered in Bombay some time ago for deodorising night-soil. Latterly, hypochlorites were advocated as a water disinfectant, and in one of the Water Reports of Calcutta this measure was advocated. It was also advocated in other places in Europe. At present, the process is somewhat changed. Instead of using sea-water, ordinary water with common salt dissolved in it was used and it was claimed for it that it was more efficient and cheaper in production. He hoped that, the plant being ready in Bombay an experiment with this substance as a water purificator would be carried out.

With regard to the purification of water by storage, he stated that the value of storage as a measure for purifying water was now well recognised, and the magnificent storage work constructed in London was sufficient testimony for its efficiency. He took up this point with a view to improve the quality of water in the wells of the City. He, for his part was not much in favour of the use of well water in view of the fact that there was so much water in Bombay and there was possibility of getting more, but the public of Bombay insisted upon retaining the wells. In Bombay some of the wells which had become polluted were covered up and the water examined again after some time with the result that there was considerable improvement in the quality. This showed that if the wells were covered up to prevent as much extraneous pollution as possible and to allow the floating impurities to settle down by sedimentation, well water might under certain conditions be used; but it would be essential to clean the well periodically to remove the sedimentation. He then replied to the criticisms on his paper. He said that his remarks were not clearly understood. He did not advocate either the Typhoid fever or Cholera as an index to the water purity standard. He did not endorse the opinion that, because it would be difficult to work out this problem in big towns and cities, therefore nothing should be done. In these days of progress in medical science this do-nothing policy could not be justified. It was not necessary in working out a standard that large towns should alone be taken. The work could be carried out in laboratories and we had also got at the disposal of Government various human laboratories in the shape of jails, military cantonments, etc., where experiments could be carried out with the greatest precision, and the results of experiments carried out at various places would, when compared and combined, afford valuable data. There was no doubt that so far as India was concerned, Koch's standard and the subsidiary standard were more or less of an empirical nature. One might take as well 20 microbes per c.c. as 1,000 for the matter of that, so long as there was no means to test its value. It was true fevers were not given under separate headings. Even the Sanitary Commissioner lumped all the fever cases under one

heading, but for military cantonments and jails, the information was more in detail and the report showed that the work of a highly technical and scientific character was carried out by the officers of Government. There was an appalling mortality from fevers in India and, with a view to combat it, it was worth-while and necessary to work in the direction of supplying purified water, and, to do that, it was necessary to have some standard to go by and the determination of such a standard was what he advocated.

He then moved the following proposition :—

"That this Congress is of opinion that Government, various Municipalities and local boards should try to work out a standard of water purity for India."

Dr. J. A. Turner seconded the proposition and the discussion of the subject was left over for the second day's sitting.

Dr. Jehangir J. Cursetji said that Dr. Katrak's was a very important proposition and should be thoroughly discussed before it was put to the meeting. At present the Koch standard had not been proved in India and therefore it was impossible to adopt it for this country. The chlorine test was impossible in the watershed of Bengal which was the home of cholera, and he therefore was of opinion that the passing of the resolution should be deferred till after discussion ; besides there was notbing on which to fix a standard and as some line should be adopted for submission to Government the vagueness of the resolution was apparent. For those reasons he proposed that discussion on the resolution should take place on the second day.

Dr. D. B. Master said that he was not convinced that the standard of water purity proposed was a correct one and he therefore preferred to have it thoroughly discussed before passing any resolution.

SANITATION IN THE HILLS OF INDIA.

By Lieut.-Colonel W. C. BEEVOR, C.M.G., M.B., R.A.M.C.

From time to time alarming outbreaks of preventable disease have startled the public by invading their hot weather health resorts ; principal among these being Enteric Fever and Dysentery, and it is with these diseases this paper alone proposes to deal.

The first consideration is, what causes these outbreaks ? and my experience of two years leads me to conclude that danger commences from the time the traveller starts on his journey.

Pressure on refreshment rooms at railway stations and dāk bungalows, at certain times of the year, entails employment of extra labour from local bazaars –the danger of which is obvious—but the purely Military element has hitherto run the gauntlet of a mass of disease creating material at each Camp on the road. This may be a startling statement, and I cannot apply it to all routes, as I have no personal experience of some—but reports lead me to consider the conditions pertaining pretty equally throughout the length and breadth of the land. Quite useless is it to erect guide posts, indicating where European and Native should wash, and attend to the requirements of Nature, unless you have a strong body of Military Police to see the orders carried out, from the very commencement of the march of Supply Columns. This was forcibly illustrated on the road to Dalhousie last year ; when I went up in March, I found the transport followers defiling every inch of the ground, in and around the Camps. Most of the mule drivers are wild hill men, utterly ignorant of sanitary laws, and it took some considerable time to put matters right. The Native seems to prefer going up-stream for purposes of defæcation, and washing himself above the area of water-supply, leaving fæcal matter on the banks of the rivers to be washed into the stream. Hence, small wonder that the water-supply becomes contaminated. Boiling apparatus is soon on the spot, but damage has already been done. Camps soon become prolific fly-producing areas, and thus food may be contaminated from the abundant fæcal deposits of the transport drivers. Time admits only of casual mention of all these conditions ; accurate study of them must give way to the important considerations I would bring before you, in the sanitary control of areas in our Hill Stations, occupied by mixed communities.

A Hill Station may of course become infected by cases which contracted disease in the plains, or on the road up ; but such are usually localised and the epidemic stamped out. I wish to bring before this Congress some most interesting facts, which prove that our sanitary arrangements, the Civil and Military, have, even up to quite lately, been very crude in most of our Hill Stations, and to suggest remedies.

With the water supplies this paper cannot deal, each area having its own peculiarities requiring local organization.

But the milk and butter should most certainly be controlled, so that none is supplied to either Civil or Military Communities except from Government Dairies. I am constantly confronted with the assertion "they do not pay." Now, could anything be more blind than such a consideration ? The Civil units pay taxes, the Military are compulsory occupants, so both demand, at the hands of the controlling elements, as perfect a condition of food supply as it is possible to arrange for. I visited many sources of milk supply to the Civil population of Dalhousie, last summer, and unhesitatingly condemn the system throughout. Not a single precaution is taken to avoid tubercular or enteric contamination, the milk is collected from semi-civilised hill-dwellers, surrounded by the usual insanitary conditions of such communities. Boiling may render disease germ innocuous, when freely carried out, but surely no one is so fatuous as to have faith in the precautionary measures carried out by Native shop-keepers ?

UNHYGIENIC BOMBAY,

Its Causes and its Remedies

BY

JEHANGIR J. CURSETJI, M.D., L.R.C.P., L.R.C.S., L.M.& S., FELL. ROY. SOC. OF MEDICINE, LOND.;

AND

DINSHA BOMANJI MASTER, L. M. S., Hon. Physn. to the Insane Parsis' Fund.

Bombay has been so long and so much more well-known to the countries of the West and to the tourists from over many lands and seas as "Bombay the Beautiful," that people have not naturally enough given a thought to Bombay the "Unhygienic." The subject matter of this paper may, therefore, perhaps, be considered by some as somewhat uncongenial and inhospitable for discussion at the inauguration of this the very first Medical Congress of its kind in India, and more specially in the heart of the very City which is welcoming its members to its friendly hospitality. It may be confessed at once that this paper lays bare, perhaps much too frankly, to the gaze of the outsiders, some unsavoury details of the insanitary conditions of a City which happens to be the Gateway of India to Western Civilization, and which justly holds the proud position of *Urbs Prima in Indis* in most other respects. But the present Congress is in its very nature a Council of Medical men specially brought together with the object of discussing the ætiology, nature, prophylaxis, and treatment of the various diseases special to a tropical country like India. Also the various defective sanitary, hygienic, and other factors and conditions which underlie them, and lead to their development and dissemination. It is but fit, then, that the City which is the birth-place of this Congress, so to say, should also be a subject for discussion as to its health conditions and its several sanitary problems at the hands of this scientific body. Owing, however, to the very wide scope of our paper and the limited time at our disposal, it is only possible to consider very broadly, and, we are afraid, much too superficially, some of the principal factors which have largely contributed to the present unhealthiness of Bombay, and their remedial measures.

It must be regretfully admitted that, notwithstanding the very large annual expenditure upon its Health Department, Bombay is still a good deal backward in sanitation. In point of both cleanliness and health, as well as in its total death-rates, it cannot, unfortunately, compare favourably with some of the larger towns of Great Britain and the Continent, notwithstanding that the ratio of its health expenditure to income is almost equal to if not more than many of them. Leaving aside the heavy annual expenditure on its Drainage, Roads, and Water-supply, the expenditure upon its Health Department alone averages, during the last seven years, between 18½ lakhs and 22½ lakhs of rupees, or between £110,000 and £123,500. Compare it with those of some of the largest cities of Great Britain, as well as with the largest Presidency towns in India, and it will be at once apparent that, generally speaking, there has been no false economy, no endeavour to avoid their legitimate obligations by the Municipal Corporation of the City of Bombay. Table No. 1, Appendix A, showing side by side (1) the population according to the latest Census returns available, (2) the death-rate per mille for the quinquennial period last preceding it, (3) the area in acres, (4) the annual income and annual expenditure on the Health Departments of the respective Municipalities, and (5) the average ratio of that expenditure to income of the three chief Presidency Cities, Bombay, Calcutta and Madras, and of the four principal cities of Great Britain, *viz.*, London, Manchester, Liverpool, and Glasgow, bears out our statements with regard to Health expenditure and Health results (*vide* Appendix A, Table No. 1).

Along with this we will give another table (*vide* Table No. 2, Appendix B) showing (1) the varying population of the City of Bombay as per census of 1872, 1881, 1891, 1901 and 1906, (2) the total number of deaths in each year, from 1872 to 1907, (3) the average annual death-rate per mille for each quinquennial period, during these 36 years, with the names of the various Health Officers during these periods, (4) the average income and expenditure on the Public Health Department during each quinquennial period, and (5) the ratio of such expenditure to income. This table will prove somewhat instructive, we believe, in studying the health conditions of the City in the light of the annual death statistics, side by side with the annual health expenditure given in it.

Unfortunately, however, there exist no exact and reliable tables of the mortality from various diseases prior to the year 1900. It would therefore be utterly futile and quite misleading to attempt to draw any approximately definite conclusions therefrom. Nor are there any statistics available in the bureau of our Health Department to shew the comparative incidence of some of the more important diseases to the proportion of the population in the various districts, and to illustrate to what extent the people are actually affected by each of these diseases irrespective of the ultimate mortality.

Both the tables taken together furnish us however with some rather doleful general conclusions. Table No. 2 in particular illustrates the fact that notwithstanding Bombay's steadily increasing health expenditure during the last decade over that of the previous three and a half decades, the death-rates have not improved in proportion. On the contrary they have become much

worse than ever before. Of course plague has contributed a very heavy toll to this mortality of the last decade. But, even after deducting this considerable factor, let us compare the still comparatively very heavy death-rates and the annually increasing expenditure with the death-rates and the health expenditure of some of the largest cities of Great Britain, given in Table No. 1, and the difference is most striking indeed.

Coming now to a consideration of the *causes underlying the present unhealthiness of Bombay*, we will briefly enumerate here some of the more important ones only, bringing out in their discussion such facts as seem to be at the root of the evils which have led to the causation and spread of plague, fevers, respiratory and various other diseases in Bombay in so large a proportion, and which contribute the chief factors in its heavy mortality returns. These causes are, of course, mostly due to defective sanitation. And for that very reason, although they offer large and difficult problems for our careful and anxious consideration, they are to a large extent not only preventable, but if sustained efforts in the proper directions are made, remediable also.

The chief defects in the sanitation of Bombay are :—

1. Overcrowding, including insufficient and insanitary housing accommodation, and the insanitary surroundings of these dwellings.
2. An incomplete and imperfect sewerage system on the water carriage principle, and a very badly placed outfall.
3. An inadequate conservancy service for the City's refuse generally, including the present insufficient halalkhore service for the removal of the city's night soil.
4. An intermittent and irregular water-supply and an enormous waste of water going on in the City from various causes.
5. The great and continuous leakages from the Malabar Hill and Bhandarwada Reservoirs.
6. Pollution of the surface of the soil, and pollution and saturation of the subsoil, with sewage and other impurities and their imperfect drainage.
7. The existence of certain low-lying lands and swamps, in close proximity to the city, known as the "Flats," the depositing on these of "Kutchra" or refuse, and their incomplete drainage.
8. Incomplete and faulty storm and surface water drainage, and the consequent bad subsoil drainage, and the high level of subsoil water.
9. The existence of (*a*) a large number of tanks and wells in a bad state of conservancy, (*b*) of quarry holes, and irregular hollows, and broken up plots of low-lying ground, badly drained, and in close proximity to populous districts, (*c*) also, the extensive new Dock Works, now being carried on on the Port Trust property, entailing large excavations over a wide area eastward of the City.
10. The existence of milch and other cattle stables, their improper location in various parts of the City, and the highly insanitary condition of many of them.
11. Peculiar social usages, customs, prejudices, and modes of living of the people.

Of the causes mentioned above, the first four are of the utmost importance in the internal health economy of the City.

We will therefore discuss these somewhat more in detail than those which follow later.

1. *Overcrowding, and insanitary and insufficient Housing Accommodation, &c.*

Bombay, with its area of about 14,300 acres and a population of fully a million, may be considered as one of the most densely crowded cities in the world. Not only have all available building areas in the City been long since taken up for building purposes, but a very large number of residential quarters in the shape of tall houses, rickety tenements, and very big chawls, have been allowed to crowd on them without much heed to the needs of the people. The scarcity of house accommodation and of available land in the City for building purposes has become so great within the last few years, owing, on the one hand, to the constantly increasing demand for a rapidly increasing population, and on the other, to the somewhat hasty demolition of several insanitary areas by the City Improvement Trust in the first year of its existence, without much regard to the sudden displacement of the people occupying them, or without any adequate provision for their temporary accommodation, that the evil of overcrowding and insanitary dwellings has been greatly accentuated. Notwithstanding this wholesale demolition of a large number of houses unfit for human habitation, and the partial improvement of others, under the Epidemic Diseases Act, a considerable number of insanitary and overcrowded tenements still remain in almost every ward of the City, and it will take perhaps another twenty or twenty-five years yet before the slow progress of the operations of the Improvement Trust will have beneficially touched a fairly large portion of them.

There are but very few open air spaces in the shape of Parks, Gardens, or other places of public resort, to act as "Lungs" to the City, compared to the urgent needs of its teeming population, densely packed in every nook and corner of it. Some of the facts and figures mentioned in Appendix E will give an idea of the extent of this overcrowding. But what it actually means can only be realised by a nocturnal visit to one or two of the many Goanese "Kurs" or residential clubs, which exist round about Cavel, Mazagon, and Dhobitalao, or to one of the large tenement chawls in some of the most crowded parts of the City like Mandvi or Nagpada. In these, sometimes as many as 15 to 20 persons sleep in each room at night, while in some of the big four and five storeyed buildings in the City, from 300 to 500 people, and even more, can be counted as their daily occupants.

No wonder, overcrowding should thus stand far and away as one of the largest, if not quite the largest, factor in the very high rate of disease and death in our midst. But, as if this baneful overcrowding was not enough of

a curse for the City, the poor of Bombay, who probably form more than 90% of the entire population, have perforce to put up with all the attendant filth and refuse lying unremoved, for several hours at times, near their doors. In this, of course, it is the people themselves who are to be chiefly blamed, even more than the insufficiency of appliances or of the minor staff, or the ineffective supervision of the executive, because of the people's perverse and filthy habits contributing to this accumulation of "kutchra" (*i.e.* refuse) at their very doors, and because of their apathy to and ignorance of even the first principles of sanitation.

Most of these tenements consist of very small rooms, ill-ventilated, damp, and unwholesome, and are literally crowded with people, many of whom go out for work during the greater part of the day, and who on return home can scarcely get more breathing space than what is obtainable in the shape of the barest sleeping accommodation at night. Their drains and house connections are faulty, and their adjoining "open (?) space," if there happens to be one at all, in the shape of a dark and narrow "Halalkhore gully," is oftener than not of a very filthy character, and reeking with all kinds of noxious odours and poisonous emanations from decomposing night-soil percolating through leaky privies. And yet, to a very large number of such residential quarters in the City, these Halalkhore gullies, or sweepers' passages, contribute the chief, if not the only, ventilating space for those living in the rooms adjoining. Generally speaking, these gullies are badly paved and badly drained and some of them are in the most filthy condition imaginable. A European can scarcely conceive such a state of things in the heart of a town like Bombay. Thus, these "open passages," instead of bringing in fresh draughts of pure air into the houses abutting on them, serve as so many storages for decomposing materials, and help to slowly but most steadily poison and undermine the health and constitutions of the unfortunate inmates in their close vicinity. To add to their sufferings there are also the sickening emanations from the accumulation, for several hours in the day, of household sweepings, street refuse, and decomposing stable litter, heaped up to overflowing in one or more unsavoury dust-bin carts, often located right under their bed-room windows. Add to these, the poisonous exhalations night and day from all the paraphernalia of leaky ventilating pipes, syphons, and traps of various kinds attached to these houses, and the sum total of the miseries of the unfortunate inmates can scarcely be more complete.

With regard to the next two causes, *viz.*, *No.* 2, *an incomplete, imperfect, and insanitary Sewerage System, and No.* 3, *an inadequate Conservancy Service for the City's refuse generally, including the present insufficient Halalkore service for the removal of the City's night-soil,* we shall pass them over here, as we have discussed them separately at some length in another paper we have contributed to the present Medical Congress. We will therefore pass on at once to *Cause No.* 4.—*This may be divided into two heads,* (*A*), *an intermittent, insufficient and irregular Water-supply, and* (*B*), *an enormous waste of water from various causes going on in the City.* The latter again may be sub-divided into (*a*) Waste from leaky underground water pipes and mains and (*b*) Waste from leaky stand pipes and taps in streets and houses during the course of the domestic water-supply.

A. It is one of the accepted axioms of Hygiene that in the effective maintenance of the general health and good sanitary condition of a city, its water-supply plays a very important part. This has been proved by actual results so often elsewhere that there is no need to emphasize it here. But if proof were wanted nearer home, the City of Bombay itself could supply a very good instance. Before the introduction of Vehar Water into the City, all kinds of intestinal and other diseases were very largely prevalent, and the dread scourge of Cholera used to be more or less endemic, and remained a permanent and very potent factor, so to speak in the high death-rates of the City. But the average annual mortality from Cholera now is not even a twentieth or thirtieth of what it used to be. And this alone shows very decidedly the very great blessing and the important hygienic factor a pure and wholesome water-supply is to a city. Several other parasitic diseases, such as Elephantiasis, Guinea-worm, etc., have also practically disappeared, and Diarrhœa and Dysentery have very largely diminished. But, besides this marked diminution in certain diseases, a great change has also come over the City in its comparatively greater cleanliness and its improved health conditions, and especially so after the introduction of the Tansa water-supply. When this supply of pipe water was first brought into Bombay from the Vehar Lake some years ago, it was considered that it would suffice for all the wants of the City for a number of years. But it was soon found to be inadequate, and a supply from the Tulsi Lake was then added. Both these, however, were again found to be in constant danger of running dry from possible failure of the monsoon, and the little Pawai Scheme, with a daily supply of only about eight million gallons of almost unpotable water, was then hurriedly sanctioned, as a temporary makeshift, in the short space of only a week, by a panic-stricken Corporation under dread of an immediate water famine. About 8 lacs of rupees were thus absolutely thrown away without the slightest addition to the City's water-supply, for the scheme was abandoned as impracticable by the Municipal Executive themselves a short while after its inception, and the pumping plant and the minor masonry works on the spot stand to this day an unmistakable evidence of an ill-considered waste of public money.

With the daily increasing demands of the city for more water, however, it was soon found necessary to adopt a well-considered scheme for the supply of water to the city, on a very large scale, in the shape of the Tansa Lake supply. These waterworks are perhaps amongst the largest and most expensive of their kind

in the world, having cost nearly two crores of rupees. The water therefrom was first brought into the city on the 31st March 1892. The people of Bombay firmly and fondly believed at the time that a plentiful and constant supply for domestic purposes was at last finally assured, and that there would be no more trouble over their water-supply, at any rate for at least another 3 or 4 decades. They were assured that there would be a supply of fully 40 gallons per head per day for every man, woman, and child in the city. But alas for these strongly pitched human expectations, and their uncertain fulfilment! The old, old cry of "Very little water, and a very fitful supply at that" was again audible very soon, especially during the hot months of the year, and the cry has grown shriller and shriller every year, till now it has become almost importunate. It is becoming quite evident, from an analysis of the figures supplied by recent observations made by the Water Department, that the magnificent promise of a daily all-round supply of 40 gallons per head per diem of 15 years ago has rapidly dwindled down to a pitiful 17, giving only 9½ gallons per head per day for domestic purposes. And it is possible it may even become an *all-round* 15 gallons per day only, within the next 5 or 10 years. This quantity, it must be confessed, is scarcely sufficient for the maintenance of a proper standard of health and cleanliness in the city, the more so as the supply is both irregular and intermittent, and, therefore, does not reach a large proportion of the population even in this meagre quantity. In many parts of the city it reaches at midnight when people are in bed, or at about 4 o'clock in the afternoon when they are away at their daily work. According to the automatic estimates of the *Venturi Meters*, which have been generally acknowledged to supply the most accurate measurement, and which were taken only in the middle of the current year 1908, the actual quantity brought into the city was found to be only 29½ millions.

B. It is an admitted fact, however, that a large proportion of this water is wasted from one cause or another. Mr. Santo Crimp calculated this waste at about 15 million gallons daily out of the 35 brought in according to his estimate. (*a*) Of this about 5 to 6 millions were recently calculated, by means of Deacon's Meters, to be due to *underground leakage from street water pipes and water mains* themselves, and about 6 to 7 million gallons as due to waste from other sources. It would thus appear that the Municipal Water Department are as much to blame as the people for this enormous waste. It is calculated that about half of the underground waste, or almost 3 million gallons, will probably be saved by the measures recently adopted by the Waste Prevention Staff of the Water Department. This will certainly improve our water-supply somewhat.

(*b*) But there will still be a preventable waste of several million gallons per diem from leaky street and house pipes, and from open taps during domestic consumption. This is mostly due to the present intermittent, irregular and very scanty domestic supply, given at very odd hours in some of the most populated districts of the city. The only means to prevent it would seem to be, in the opinion of many, a constant supply at high pressure, *i.e.*, at a uniformly effective pressure, under proper control, from the distributing or balancing reservoirs.

Reverting to the figures supplied by the Venturi Meters, if they are correct, can this *all-round* present average supply of about 17 gallons per head be considered reasonably sufficient for the proper maintenance of the health of the city? We need hardly reiterate that we approve of the complete adoption of the water carriage system for the removal of our sewage and night-soil, as fully as any body else, *if all the conditions necessary for its proper removal are obtainable.* But as matters stand, would it be wise, would it be safe, to insist upon passing the night-soil of the whole city into our sewers, with such a dangerously low amount of water for domestic, trades, and all other purposes, such as watering of roads, flushing of sewers and water closets, etc.?

More often than not, owing to this intermittent and scanty supply with low pressure, water from the mains does not reach the tanks on the upper floors of houses. As a result, the flushing of the water closets is perforce carried out perfunctorily, creating an intolerable nuisance from foul smells to the great annoyance of the residents. And yet our Executive Health Officer thinks that "The amount of water-supply per head of the population is amply sufficient to remove the night-soil by the water carriage system. At the present time all the waste water of the Nahani and the bathing places discharges on to the open gully drain, and it has been frequently pointed out that all this water could be utilised for flushing the drain of the water carriage system, and no night-soil left in the privies or gullies." In this opinion, supported in his letter of the 24th November 1905, the Executive Engineer also concurs. They both agree in thinking that "*all* the conditions absolutely necessary for the proper and efficient working of the water carriage system exist," and this of course includes the provision of sufficient water for flushing purposes. But the Municipal Commissioner, Mr. Edwardes, in his letter, dated 10th September 1907, says, "Speaking purely theoretically I have no doubt that the Health Officer's view is correct, but the full benefit to the city from the water carriage system can only be obtained if there is a constant and sufficient supply of water for flushing purposes. This I believe is not the case at present, and in more than one large building of recent construction in which water closets have been insisted upon, the tenants have been put to extreme inconvenience by the absence of sufficient supply for flushing purposes. I am (therefore) not inclined to press the full water carriage system too rapidly upon the city." And many sober minded persons will fully agree with this common sense opinion of the Commissioner.

And why has this been so? Why is the promised supply of 40 gallons per head not obtainable? We are

not concerned as to how this is to be remedied. Nor is it material to our purpose to enter minutely into the details of the various causes of this deficient supply, or the exact figures of this deficiency. All we want to point out is the broad fact, that the present water supply is *not* enough even for the people's ordinary domestic wants, and as even that insufficient supply is irregular and intermittent, fresh elements of danger to their life and health are super-added. Such an irregular and intermittent supply of water necessarily leads to a state of partial vacuum for some hours in the under-ground water mains and pipes. As a consequence, a direct absorption of poisonous gases, as well as of various disease germs, such for instance, as of Cholera, Dysentery, Diarrhœa, Enteric Fever, etc., from the polluted and decomposing liquids in the soil, escaping from some of the leaky sewers laid in their close proximity, takes place. When it is considered dangerous, owing to the absorption of these sewer gases, to allow even the passage of a water pipe through the flushing tank of a drain or a privy, this danger would necessarily be much more accentuated in the case of underground water mains close to sewers.

Cause No. 5.—(*A*). Besides the hidden underground waste from the water mains and street pipes, another very large source of waste, also more or less unseen at its source, is *the leaky condition of the Malabar Hill and Bhandarwada Reservoirs* and of the large Filter Beds attached to them. The waste of water from these two sources alone is estimated at about two million gallons per diem. It is the opinion of many competent observers, confirmed by investigation, that the leakages from the two Reservoirs constitute a very fruitful element in the causation and spread of Malarial Fevers in the population of the districts adjoining them, which include some of the best residential quarters on the Malabar and Kumballa Hills, and the greater portion of the Mazagon district.

B. Waste of Water above ground.—This waste of water, which mostly occurs during the course of the domestic supply, is estimated at about 4 to 5 million gallons per day. It generally occurs from leaky pipe joints and leaky taps and stand pipes in streets, and from water taps left open in houses, and is chiefly due to the gross carelessness and perverse negligence of the people themselves, who use these taps and keep them open all day long for washing, bathing, cleaning pots and pans and other purposes.

It is scarcely surprising that, with this enormous daily loss of several million gallons from one cause or another, the city's subsoil should be saturated with water, especially in the low-lying districts, or that the level of the subsoil water should remain more or less high, and should contribute largely to the high rate of mortality prevailing in the city.

Cause No. 6.—Pollution of the surface of the soil and pollution and saturation of the subsoil with sewage and other impurities, and their imperfect drainage.

We have already alluded to some of the ways by which this sort of pollution takes place very lengthily in our other paper on The Defects in the Disposal of Sewage and Town Refuse of this City, and will not therefore refer to them here.

Cause No. 7.—The existence of certain low-lying lands and swamps in close proximity to the City, known as the "Flats," the depositing on these of "kutchra" or refuse, and their incomplete drainage.

A special feature in the imperfect drainage and pollution of the surface of the soil and subsoil of some of the low-lying districts of the city may be referred to here. This feature is connected with the evils created by the filling in of certain low-lying lands and swamps ordinarily known as the "Flats," and their insufficient drainage. These Flats are in close proximity—almost within a mile or two—of the city, and are so many reclaimed areas of swamps and low-lying grounds filled in with the city's refuse, which is ordinarily known in the vernacular as "kutchra." The principal Flats in the city are the Byculla, Tardeo, and Mahalaxmi Flats, and the swamps in the neighbourhood of De-Lisle Road, extending more or less towards tho Dadar railway station. They have been characterised by the late Mr. Santo Crimp as "insanitary and dangerous." The filling in of these Flats went on for a number of years, and is now over. But the lands thus reclaimed, unfortunately without a well-considered provision for their proper drainage, have been recovered at a considerable cost to the health of the city.

In the reply sent by the Corporation to Government in October last, submitting their views on certain proposals for the development of Bombay city, they rightly observe, "Had these areas (reclaimed Flats) been properly developed, which the Corporation had expressed their willingness to undertake, and should they have been vested in them as requested, they would have proved most valuable for the healthy expansion of the city." But the Government, instead of vesting them in the Corporation, chose to hand them over to the Improvement Trust, and as a consequence their effective development has been very effectually hindered, if not quite checked, and they continue even now to be as "insanitary and dangerous" to the city's population as when they passed into the hands of the Improvement Trust ten years ago.

Cause No. 8.—Incomplete and faulty storm and surface water drainage, and the consequent bad subsoil drainage and high level of subsoil water.

This group as a whole constitutes, in the opinion of many experienced observers, another important factor in the insanitary condition of Bombay generally, and in the incidence and spread of malarial and various other fevers, and especially of phthisis and other respiratory diseases. Unfortunately, for the proper discussion of this subject on a correct statistical basis of reliable mortality returns of the various diseases, we have no definite statistical data to support this opinion incontrovertibly. But for what these data are worth, they at least serve to shew that both the incidence and mortality of fevers and various other diseases have been, generally speaking, considerably higher in the low-lying, undrained, or imperfectly drained districts of our city than in those

properly drained and situated on a higher sea-level. This is of course what is borne out by the experience of other large towns similarly situated. We will, however, refer to this statistical aspect a little more in detail later on.

Mr. Santo Crimp in his valuable report on this subject, submitted in the year 1889, remarks that the interior plain of the subsoil of Bombay is of clay, and is not therefore amenable to drainage by means of subsoil channels. He is of opinion, however, that " proper surface drainage by means of suitable channels, and the prevention of liquid pollution of surface and subsoil, would dry them, and the subsoil would take care of itself."

He also pointed to the luxuriance of crops on the Matunga Farm, and to the extremely damp condition of the soil about the Gilder Street chawls and the Union Flour Mills at Chinchpokly, and inferred that "even small volumes of surface water are thus sufficient to permanently moisten large areas of subsoil." When this surface water happens to be contaminated with sewage and other impurities, as it generally is, and percolates into the subsoil, it naturally forms a fruitful nidus in the soil for a luxuriant crop of disease germs. To a question put him, whether the subsoil water of Bombay was higher than it should be, his answer was, " It is decidedly so in many parts of the city due to easily preventable causes." And he considers the source of this subsoil water to be, " the rains in the wet season, the sewage in dry weather, and leakage from water taps." To these may be rightly added the enormous underground leakages from our leaky water pipes and mains, and from the two reservoirs—the Malabar Hill and the Bhandarwada—as clearly revealed by the Special Water Engineer's reports recently submitted. Mr. Santo Crimp is also of opinion that a high death-rate from respiratory and lung diseases in Bombay is largely due to a damp subsoil and bad or no drainage, and that people largely suffer owing to a saturation of the subsoil under some of the streets and blocks of houses. Most of the measures suggested by him for the proper drainage of surface and subsoil water have been, we believe, already carried out, and others are still in progress. But even now the drainage of our surface and subsoil cannot be considered as satisfactory by any means, and an early completion of the works in the directions indicated by him is necessary before they can materially benefit the health of the city.

Another eminent expert, Mr. Baldwin Latham, refers to the late " Dr. Henry Cook of this city drawing attention to the increase of phthisis going on in Bombay, ascribing it to the bringing in of additional water supplies without adequate provision being made for the removal of such water after use, and which consequently tended to produce a state of dampness in the soil, which condition favors the development of this class of diseases."

He further observes, " It has been found that all those parts of Bombay which are the most unhealthy are without exception those into which, in addition to their own impure waters, the polluted underground waters flowing from other districts circulate, and probably the most unhealthy district is that of Kamatipura."

Referring to a table of births and deaths in Bombay, furnished him by the Health Officer and given at page 39 of his book, " The Sanitation of Bombay," he also observes: " It may be only a co-incidence, but I find that so great had been the progress made in filling up these flats in 1880 as to require a reconsideration of the surface drainage project, and at this time deaths from respiratory diseases increased from 1,974 in 1880 to 3,779 in 1881, and have gone on increasing from the latter year up to the present time 1889." This significant fact is further corroborated by another table given in Mr. Santo Crimp's report already referred to, which carries forward the sad tale of this regrettable mortality up to 1898. It shews that the death-rate from respiratory diseases in general, as well as from phthisis, continued to rise almost steadily, with only slight variations for the better, possibly due to inaccurate registration, until in the year 1898, the deaths from respiratory diseases reached the enormous total of 8,423, or more than four times what it stood in 1880, *viz.*, 1,974 ; and those from phthisis 5,624, or more than double compared to 2,710 in 1880. On a further analysis of the annual death-rates from various causes furnished us by the kind courtesy of the present Health Officer, we find a similar rise noticeable in deaths from diarrhœa and dysentery, from the years 1875 to 1881. In the year 1874, the deaths were 1,648. From 1875 to 1881 they varied between 2,062 to 3,847, except in 1880, when the number fell to 1,728. Then there was a marked diminution from 1882 to 1893, the numbers varying between 1,618 and 1,823. There was again a marked rise from 1894 up to 1905, the numbers varying between 2,344 in 1894 and 4,306 in 1899 and 8,676 in 1900, and thenceforward keeping between 3,716 in 1901 and 3,391 in 1905. Although almost all other diseases thus show this sort of rise, yet, strange to say, the returns of mortality from all kinds of fevers for the same periods do not shew the same rise, but only moderate and irregular exacerbations in certain years and marked falls in others.

In the report recently submitted by the Fever Committee the *apparent* inference drawn by them is that, " an examination of the figures (of the so-called ' Fever Statistics ') submitted with the Government Resolution, shews clearly that there has been a decided decrease of late years in the number of deaths from fever, not only in the city as a whole but in every ward, and among every race inhabiting the city, and this in spite of the fact that within recent years the population of the city has enormously increased." But the general experience of a large number of local Medical Practitioners has been that, along with other diseases, the fevers also have been prevailing much more extensively in the city within the last 20 years or so than at any time before. Our experience of very bad outbreaks of Malarial Fevers during the past few years, in various parts of the town, tend to strongly support this conclusion. The Committee are wise, therefore, in not only not trusting to these official figures, but in discarding them altogether in the very next passage of their report. They

evidently recognise this aspect of these "Fever Statistics" when they say, with considerable reservation, "If these figures (death returns from Fevers) can be relied on, it is manifest that there is less cause for complaint under this head now than formerly. It is generally held, however, that these statistics are inaccurate, and the Committee were led to understand that complaints regarding the increased prevalence of fevers had notoriously increased of late years." They further remark: The evidence derived from the recorded number of deaths from different causes in the city is of little value. The cause of death is far from being accurately registered. A comparatively small number of persons are attended during their last illness by qualified medical men, so that the cause of death is often ascertained by information furnished by friends and relatives. The registration of the cause of death under these circumstances is very inaccurate." This is further emphasized by the evidence of the present Executive Health Officer himself, quoted in the Fever Committee's report. It is possible also that the mortality returns of fevers in general, as well as of many other diseases, have been very largely mixed up and vitiated by the introduction of deaths from Plague since 1896. Indeed the Fever Committee lay considerable stress upon the high mortality returns from Plague as forcing them to the conclusion that "the increased unhealthiness of the city must in large part be accounted for by the presence of this disease."

In our humble opinion, however, this "increased unhealthiness" is due to the presence in our city of the neglected filth of years, in various shapes, affording good camping ground for rats and vermin, and thus to Plague. It is also due to the inefficient and imperfect conservancy of the city generally, affording favourable conditions for their propagation, rather than to the advent of plague *per se*, as might be supposed by some people. It may be readily conceded, however, that the enormous increase in the total mortality of the city during the last 10 years is certainly largely due to Plague.

In their report, the Committee give great weight to and accept the value of the evidence furnished by the annual death-rate as a means whereby to gauge the health of the city. But we are afraid we cannot quite do so without taking into consideration the different factors and conditions underlying them, which greatly detract from any statistical value they may possess at first sight. The Committee themselves rightly point out that "the accuracy of the death-rate figures will largely depend on the correctness with which the population is estimated. The difficulties connected with the enumeration of the population of an Eastern City like Bombay are too well known to require repetition here." It is roughly estimated that the annual fluctuation in the city's population, by immigration and emigration, lies somewhere between fifty and one hundred and fifty thousand persons at different seasons. It also varies largely from other causes from year to year in the ten years of a census period. During the last decade Plague has been a very important factor in bringing about this large fluctuation every year. The incidence of famine in certain years in the Presidency has also greatly influenced the population, as well as the general health conditions of the city, not only in the years of their incidence, but also in one or two succeeding ones. We cannot, therefore, safely rely upon these annual death-rates—even if they are "absolutely accurate" as emphatically asserted by our Health Officer—as reliable data for drawing any definite conclusions as regards the healthiness or otherwise of our city. And the Fever Committee also are, therefore, justified in concluding that "while the actual number of deaths recorded in the city may be exact, the annual death-rate calculated on the population of the city, as estimated at the decennial census enumerations, can only be approximately near the truth. Too much stress must not therefore be placed on slight variations in the death-rate of the city."

In this connection, we beg to again draw attention here to Table No. 2, Appendix B, with special reference to the two columns of the total number of deaths, and the average death-rates per mille. A study of these death returns since 1872, incomplete and inaccurate as they are, serve, however, to indicate one or two broad conclusions clearly enough. For instance, it can be readily seen from these tables that the year 1900 was the year of the highest mortality from most of the principal diseases during the last 35 years, or even in the whole history of this city. The total mortality for that year was 79,350, out of which 12,522 were deaths from respiratory diseases, 8,199 from phthisis, and 7,937 from fevers, though the deaths from Plague were only 13,285, which, compared to the previous years, were about as low as the lowest recorded up to 1905. But side by side with it there is another fact which strikes one rather forcibly, and that is that from the year 1900 up to 1907, there has been a very great and a very sudden drop in the mortality from almost all important diseases, excepting Plague, and this last also seems to be rapidly declining during the last quinquennial period from 1904 to 1908. For instance, the fall in respiratory diseases has been from 12,522 in 1900 to 5,804 in 1901, 7,520 in 1902, 7,101 in 1903, 7,339 in 1904, and 9,103 in 1905. So also in phthisis, from 8,199 in 1900 to 6,516 in 1901, 3,957 in 1902, 2,842 in 1903, 2,971 in 1904, and 2,558 in 1905. So also in fevers, from 7,928 in 1900 to 7,921 in 1901. 4,518 in 1902, 2,333 in 1903, 3,416 in 1904, 2,878 in 1905, 4,882 in 1906, and 3,633 in 1907. Similarly in other diseases. And why? What cause or causes have so beneficially conspired to this sudden and extraordinarily rapid fall? A reference to the Table No. 2 will show, that while the mean or average death rate per mille for the quinquennial period preceding 1896, was 30·64, that preceding 1901 was 65·51, and that for 1901 to 1905 was 56·32. We are not aware of so large and sudden a fall, from one quinquennium to another, of nearly 25 per cent. in the mean or average death-rate of any city in the world, no matter

how perfect its sanitary arrangements, how complete the supervision, and how well organised the conservancy service of its Executive. It is true, the sanitary condition of the city has improved considerably since 1900. It is true, also, that the total death-rates, as well as deaths from various other diseases, have apparently considerably fallen. But even our energetic Health Officer cannot deny, indeed he has not, that there are hidden sources of error in these death returns, and that there is also ample room for a great deal more improvement in the various factors contributing to the ill health of the city.

This sudden fall in mortality may in part be accounted for, however, by the fact, that the very large number of deaths from plague, between 1896 and 1905, may have swept away so many weakly persons who would have otherwise died from other diseases, that the death-rates from the latter may have been perceptibly diminished, as seen above. Or, again, the famines of the years 1897-98 and 1899-1900, which led to an exceedingly large influx of starving people from the mofussil into Bombay and a consequent large mortality super-added to that of Plague, might have so increased the death-rates for the years 1898 to 1901 as to render the contrast between them and those of succeeding years more exaggerated than otherwise.

Again in the Fever Committee's own words, "It is well known to those who have had the opportunity of studying the plague in the city, that only a portion of the total deaths actually due to this disease (plague) are recorded as plague deaths. Many deaths which are really due to plague are registered under such terms as phthisis, fever, asthma, and the like, in order that the friends of the deceased may avoid the inconveniences associated with anti-plague measures."

Had these deaths, which, according to the Committee's estimate, were about one-tenth of the total deaths in the city, been eliminated, the returns for the years following 1900 would indicate a lower mortality from diseases other than plague than existing returns do.

Such would be the logical conclusion from an analysis of the figures given in Table No. 2, and it would tend to shew up Bombay to be a comparatively much more healthy city. But the actual state of things points the other way, we are afraid. If we glance for a moment at the table already quoted, and take the period of the last 26 years (during which the Health Department of the city may be said to have been working under a fairly organised basis), we will find that in the first part of it, *i.e.*, in the 15 years from 1881 to 1895, the death-rates varied between 25·96 in 1886, the lowest figure touched, and 33·25 in 1894, with a mean annual death-rate of 29 per mille in those 15 years. Counting the second or the plague period of 12 years, from 1896 to 1907, even after entirely eliminating the very heavy mortality from plague during these 12 years, so as to compare both the periods under similar conditions, as far as possible, the mean annual death-rate still works out at as high as 40·35 per mille. This certainly does not point to any improvement but to a serious retrogression in the mortality, *i.e.*, in the general health of the city.

In this connection, the accompanying little table of death-rates, calculated on each of the five *census* years of the city of Bombay, from 1872 to 1906, and shewing, side by side with the total population, the total number of deaths, and the death-rate per mille, at each of these periods, is also rather suggestive. (*Vide* Appendix C, Table No. 3.)

The table serves to shew that although there was an increase in the city's population in the year 1881 by more than a lakh and a quarter over that of the year 1872, the annual death-rate had actually fallen from 29·40 to 28·26 per mille. But, ever since then, the death-rate in every succeeding census period unfortunately shews a steady and marked increase over its predecessor, except in the very last one of 1906. And even that one shews a much higher death-rate, even after excluding the enormous number of deaths from plague, than that of the years preceding that of 1901.

In this connection we will quote a passage from the recent review by the Standing Committee of the last Administration Report of the Municipal Commissioner, for the year 1907-1908. In it they say, "Against the recorded birth-rate of 19·97 per mille, the death-rate for the year is put down at 39·56, the lowest registered since the year 1896. But, lighter as has been the year's bill of mortality than any in the past decade, the Standing Committee cannot help regretting the fact that the annual toll paid by the city is still a very heavy one, and that, even after due allowance is made for the ravages of plague, the health conditions of the city scarcely reveal any improvement on the pre-plague period."

But perhaps the best index to the general health of the city is afforded by the gradually increasing death-rates of the Parsi community, as seen in the accompanying table No. 4. (*Vide* Appendix D, Table No. 4.)

It is generally acknowledged that births and deaths amongst the Parsis are much more accurately registered than amongst any other Indian community in the city, and these rates can therefore be fairly relied upon. The Parsis have come to be recognised as a compact little community by themselves, living under much better social and sanitary conditions than all the other communities of the city, Europeans alone excepted. And yet, as can be seen from this Table No. 4, their death-rate has been steadily on the increase for a number of years past. In years gone by, especially in the two decades between 1872 and 1881, and 1882 and 1891, the mortality returns of the Parsis were very low, indeed lower in some years than even those of the very small European community living in our midst. But now, notwithstanding their greatly increased education, more advanced ideas of sanitation, and better mode of living, their mortality has, instead of

diminishing under these improved conditions, considerably increased. Their average weekly mortality now ranges from 24 to 40 deaths as against 16 to 20 twenty-five years ago, and their annual death-rate per mille, which was 21·65 in the decade between 1882 and 1891, has risen to 31·36 in the last ten years between 1898 and 1907.

Table No. 4, Appendix D, also serves to shew that the average annual death-rate of the Parsi community has been more or less steadily on the increase during the last 36 years. Counting from the decennial period between 1872 and 1881, in which it stood at the mean annual average of 23·36 per mille, it fell as low as 21·65 between 1882 and 1891, and went up to 29·26 in the decennial period between 1892 and 1901, and 27·95 in the quinquennial period between 1902 and 1906.

The one broad inference, then, that we can draw even from these admittedly inaccurate statistics is that the health of the city is still in a bad way, and that it wants a more constant and careful looking after.

Cause No. 9.—The existence (a) *of a large number of tanks and wells*, both private and public, *in a bad state of conservancy*, (b) *of quarry holes*, and *irregular hollows*, and *broken up plots* of *low-lying ground*, *badly drained*, and in close proximity to populous districts, and (c) the extensive *new dock works*, now being carried on on the Port Trust property, *entailing large excavations* over a wide area eastward of the city. This group constitutes another important source of the present unhealthiness of the city, and more especially of malarial fevers.

(*a*) Many of our public tanks and wells are not carefully looked after. This can be plainly seen from their foul and stagnant condition, and the presence of decomposing vegetation in them. They have in certain cases proved not only sources of intolerable nuisance from the offensive smells emanating from them, but are believed by many medical men to be the cause of malarial fevers in their neighbourhood. As instances of foul tanks which required filling in may be cited the recently filled up Gilder Street, the Babula, and the Cowasji Patel (partially filled in) tanks, and of the uncleaned tanks still in existence, the Nabob's, the Nacoda's, the Mint Road and the Dhobi Talao Tanks.

With regard to the Dhobi Talao Tank, the complaints have so multiplied year after year that the Commissioner has been at last, quite recently, obliged to ask for sanction from the Standing Committee for the necessary expenditure to get it cleaned. Some of the wells on the Esplanade, and the ponds and tanks and irregular hollows and pools of water in the compounds of some of our spinning mills, as well as some other neglected wells in different parts of the city also predispose powerfully to illness in their neighbourhood.

Again, a large number of the *wells situated in private dwellings* have also been found to be exceedingly foul-smelling and contaminated by sewage matter draining into them from the polluted subsoil water, or from the nearest leaky drains. The various analyses of samples of water from a large number of public and private wells, made by the Municipal Analysts themselves within the last 6 or 7 years, and which formed the bases for declaring a large number of these wells unfit for potable purposes, and, therefore, to be summarily closed up, serve to shew that the contamination was probably due to sewage matter from the contaminated subsoil. In his last half-yearly report, the present able Municipal Analyst says, " Seeing that nearly 85 per cent. of milk samples sold in the bazaar are adulterated, and in the majority of cases grossly adulterated, I would urge the desirability of having an Act passed to regulate the sale of milk. Thirty samples of well waters were examined, and all of them were found to be unfit for potable purposes. Very few wells (hardly 3 per cent.) in Bombay are free from contamination and fit for potable purposes." Such a Milk and Food Adulteration Act is absolutely necessary in the best interests of the people of Bombay.

In connection with these tanks and wells, etc., it is interesting to note that the Acting Executive Health Officer, in his letter of 25th August 1908 remarks, " Another unquestionable breeding place for anopheles mosquitoes lies in the numerous wells to be found scattered throughout the Fort." And he might well have added, throughout the whole city. The late Mr. Santo Crimp points out, in his report of 1899, that " the tanks in the city may be contributing causes to various diseases, and they form receptacles for filthy sullage water from open channels. and from liquids draining from places used by large numbers of persons for natural purposes, and from decomposing bodies of dead animals rendering the surrounding air unwholesome and offensive, and they most probably supply breeding places for mosquitoes." He suggests that they should be filled up with proper drainage precautions, and converted into play-grounds or gardens.

(*b*) Besides the tanks and wells, there exist innumerable large and small irregular, broken up pieces of waste land, scattered in different parts of the city, as well as unwalled tanks and shallow hollows and pools of water filled with rotting vegetation, and (*c*) large excavations necessitated by the new Dock operations in close vicinity to Fort North, which afford the most favourable breeding ground for the germs of various diseases and especially of malarial fevers, and have necessitated the appointment of a Special Committee for inquiring into the causes, &c., of these malarial fevers by Government in November last.

Cause No. 10.—The extremely insanitary condition of most of the stables, and especially of the milch stables, and their improper location in the very midst of a crowded population. This is another factor closely connected with the causation of malarial and other fevers in general, and a special one, perhaps, with regard to the causation and spread of enteric fever, and other febrile diseases of a zymotic character, such as small-pox, measles, diphtheria, whooping cough, etc., and also of cholera, diarrhœa, and dysentery.

A Committee of the Corporation, appointed to investigate this subject, has carefully gone into the matter

and has found a state of things with regard to them which is highly dangerous to the health of the people, and scarcely creditable to those responsible for them.

It is stated authoritatively in that report, that *only two out of nearly 230 milch and other public stables complied fully with the requirements of the Municipal Act, and that by far the largest number are very defective in many respects from a sanitary point of view.* We will not enter into the details here. But what with the extremely insanitary condition of these stables, the filthy condition of the cattle located in them, and the badly contaminated water supply on the premises used for washing and cleaning purposes, as well as for the adulteration of milk, there can scarcely be any doubt that the milk supply of the city from such dangerous sources must be highly contaminated, and must prove a fruitful cause, both as a productive as well as a carrying agent, of the germs of various diseases, and be responsible for the large number of deaths following therefrom.

Cause No. 11.—The peculiar social customs, prejudices, and modes of living of the people and their dense ignorance of even the first principles of sanitation.

It must be admitted that a large portion of the insanitary conditions prevailing in and outside the dwellings of the poorer classes is directly due to some peculiar and perverse habits of the people themselves, their ingrained prejudices and stupidity, their want of personal cleanliness, and their ignorance of personal hygiene. The location of the house well close to the privy, washing of soiled or dirty linen, and the scouring of household utensils, near the very well from which they oftentimes drink, or close to the stand pipe from which they draw their daily water supply, the almost ceaseless waste of water from the constantly running water taps making the ground-floor damp and unwholesome from constant soakage, the shutting up at night of every door and window, or even closing up the only window if it happens to exist in the bed room, the nailing up of all spaces for ventilation, and the apathy and indifference to help the authorities in improving their condition, all together constitute a most difficult problem for the anxious consideration of the executive, and complete the painful picture of a stolid and unconscious ignorance associated with great poverty, such as can scarcely be seen even in the poorest civilised town of the West. Although these things may not be easily preventable all at once, yet there is ample room for the exercise of certain corrective and educating influences, leading gradually up to considerable improvement.

Having thus somewhat lengthily discussed the chief Defects in Sanitation which have contributed to make Bombay the Unhygienic, we will now briefly refer to some of the principal Remedies.

The chief measures that suggest themselves are:—

1. *The relief of overcrowding.*

Overcrowding is generally acknowledged to be one of the most urgently pressing evils in the city at present. Constant attention is therefore needed to lessen it as quickly as possible. With this object in view, the steps that commend themselves are :—

A. *Removal of insanitary areas*, and an *early provision* in their place of *sufficient housing accommodation of a cheap and sanitary character* in the suburbs and in the city itself, more especially for the poor, and the lower middle classes.

It will be readily admitted by every one who has the slightest acquaintance with the internal conditions of the people living in the city, that insufficient and insanitary housing accommodation is the one evil that presses most heavily and most banefully upon the health, the purse, and the peace of mind of those who have the misfortune to be of the lower and lower middle classes, in other words, the poor of the city,—and they can be counted as fully nine-tenths of its population, if not more. In fact, it lies at the bottom of considerable illness, ill health and death amongst them. An early relief from this terrible load, so heavily weighing upon the inhabitants of the city, is, therefore, most urgently needed. There is certainly not enough room now within the narrow precincts of the city to accommodate a million people unless all available areas are built upon. Some of the districts, as we have already seen while discussing the causes, are very badly congested and as a natural consequence their toll of human life is simply apalling. For instance, in the census year of 1901, the death-rate per mille for Mandvie was 102·95, for Kumbharwada 108·48, for Dongri 111·18, for Kamathipura 111·28, and for Girgaum 129·28, while their birth rates have been as low as 15·41, 16·08, 17·0321, 45·00, and 22·93 respectively. It is highly necessary, therefore, that some of these insanitary slums in crowded areas should soon pass into the hands of the Borees, and their demolition completed as quickly as the erection of new residences on sanitary lines for the displaced inhabitants will allow. To do this quickly and on a larger scale than at present, however, it is equally necessary that the population should be spread out into the suburbs as much as possible. Hence it is very desirable that in any schemes for the present as well as the future development of Bombay, the needs not only of the poorer classes, but of the middle and the lower middle classes as well, should be taken into special consideration. For any scheme for the future expansion and development of the city, whatever its nature and scope, would certainly be incomplete without due provision being made for the inclusion of sufficient housing accommodation of this character. No better arguments could be found to emphasize the urgency of this embarrassing Housing problem than those furnished by the very telling high death-rates of the more congested portions of the city published in every one of our Health Officer's quarterly reports during the last decade. From these, as well as from a comparison of the annual death-rates of the various districts of the city, it will be seen, that all other adverse conditions being approximately the same, the mortality as well as the prevalence of disease mostly follow in the line of the density of the population per every acre of land occupied, and that those districts which are very sparsely

populated almost invariably show the lowest mortality. This is an universal axiom which requires no proof. As has been rightly pointed out in the Fever Committee's Report, "This (overcrowding) has largely arisen from the absence of any definite scheme of development for a rapidly increasing city. Certain areas of the city are densely crowded with houses and people, while other areas, often equally accessible, are sparsely populated. In this respect the districts known as Kumbharwada, Nagpada, and Kharatalao, with a density of population of 711, 647 and 646 per acre respectively, may be contrasted with the comparatively adjacent areas of Tardeo, Mahalaxmi and Worlee, with densities of 123, 28, and 38 persons per acre, respectively." In the future expansion of the city, therefore, a definite and well considered scheme, whose component parts might be made so elastic as to be easily adaptable to the needs not only of its present but of its future development, is of paramount importance, and requires to be well thought out in its entirety.

But this density of population per acre is not always a correct index or test of overcrowding in a particular locality, and it is oftentimes even misleading. It may be that in a large area of land it is actually low per acre and yet portions of the area be overcrowded with buildings while others are only sparsely populated, as is seen in the instances quoted above from the Fever Committee's report. In many districts of Bombay this is the actual state observed. The true test of overcrowding of a district is, therefore, much better gauged by the number of buildings standing on it, as well as by the number of the occupants in relation to the number of rooms in these buildings. This is well illustrated by the small colony of comparatively poor class Parsis residing in what are known as Mr. Murzban's Poor Parsi Chawls at Tardeo. In it, the number of buildings, about two dozen, is considerably larger in proportion to the area of land occupied, and consequently the number of their occupants to every acre is perhaps also larger. And yet, although the number of people residing there is about 600, their total annual death-rate, even during the most violent period of plague, when the annual death-rate of the entire Parsi community was over 33 per mille, was as low as 20 per mille, and in 1903 only 6 per mille, and there has not been a single indigenous case of plague there during the last twelve years. This is of course due to the correct and even distribution of the occupants to buildings and rooms, and the erection of the buildings on proper sanitary principles.

The first and most important step to this end then, *viz.*, to improve this overcrowding on the right lines, lies in the hands of our City Improvement Trust, and that step is to concentrate their immediate attention towards demolishing and rebuilding in various *small* insanitary areas in the different districts of the city *first*, before taking up large street schemes, or other more extensive and ambitious improvement and reclamation schemes.

This policy was very strenuously urged on the City Trust by the Municipal Corporation so far back as the year 1901. Even at that time the Corporation considered it extremely desirable and essential that in order to carry out improvement operations with this end in view, "the Improvement Trust should in the first instance make a sanitary survey of the whole city, and prepare a general skeleton scheme, in which particular schemes might find fitting allocation, before resolving upon undertaking separate proposals."

What then should be the nature and extent of this Housing Accommodation, and in what directions should it find proper location and expansion?

A. The operations of the Improvement Trust, instead of relieving the overcrowding, have unfortunately, if anything, considerably accentuated the evil. In the first years of their existence they began by blindly demolishing a large number of residential structures in various parts of the city, without foreseeing and providing sufficient accommodation for the large number of people that were thus unhoused. And the result has naturally been that the displaced people have found some sort of a roof shelter by cramming themselves into the already overcrowded chawls and tenement-rooms of their relations and friends, in the close vicinity of the very areas demolished. The Trust woke up at a very late hour to this disturbing factor in their calculations, and began building a few *sanitary chawls*. But these have been found quite inadequate for the intended purpose, and, financially too, the building schemes have been found to be a failure, the return of rents on the capital being barely or even less than 3 per cent. It is true that the Trust have made provision in their various street and improvement schemes for building a considerable number of chawls, in different districts, on the sites of some of the demolished areas which are now being rebuilt. It is also true, that, as already said, they have built a certain number of these chawls ere now, and that they have made an aggregate provision for the erection of a number of tenements sufficient to accommodate about 30,000 people by the middle of the current year. We do not know that they have come up to their intended programme yet. But, even with this effort, we are afraid they will not be able to cope, single-handed, with the constantly increasing demand for more accommodation. The general opinion is that the future efforts of the Improvement Trust, of the Municipal Corporation, and of other large bodies intimately concerned with the present and future industrial and commercial well-being and prosperity of the city, such as the Port Trust, the two Railway Companies, and the many large Mill industries of the city, should be joint ones, and on the lines of mutual co-operation. These efforts should in the first instance be directed to the *creation of a fairly large number of blocks of tenement houses or chawls, in different parts of the city, in the opened up areas of overcrowded and congested centres.* They should be built on approved sanitary principles, and, wherever possible, near the business quarters of the town, and they should be specially intended *for the labouring classes.* Such buildings how-

ever should not be designed in future after the pattern of the cold and repulsive "Sanitary structures" erected, within the last few years by the Improvement Trust, on the old Agripada and Chandanwadi sites. It appears as if they had been built with an eye to the strictest economy, and for that reason look cold and bare, and may well take the palm for being about the most ugly looking structures in Bombay. They are constructed, we are afraid, without any suitable provision for protection from wind or rain blowing in from the open verandahs, and this actually necessitates an improvised protection made up by hanging over the verandahs old gunny bags and dirty rags! When we say this, we of course do not mean for a moment that the structures should be very ornamental; we mean only that they should be made a little more comfortable and convenient; even a single cheap coating of limewash over the bare brick walls would so improve their appearance as to attract people and not repel them.

B. It is evident, however, that a dozen or two of such sanitary chawls in the city can scarcely affect in any appreciable degree the relief in the overcrowding. As we have already said, the relief, to be at all effective, should be on a much larger scale. As, however, there is not room enough for building available in the city, and the prices of land rule high, the most natural and economical course that has for a long time suggested itself, is to turn attention for that relief to *a properly regulated expansion towards the large unopened areas of vacant land in the suburbs to the north of the city, in the districts of Matunga, Sewri, Dadar, Sion, Worlee and Mahim, and the large stretches of open land in the Salsette district further north.* Schemes of expansion in this northerly direction towards the suburbs, would more especially *suit the needs of the lower middle and middle classes.* But to bring such building schemes into early operation, special facilities should be given to private capitalists to encourage them to build for this special purpose, and to rent them to the intending occupiers at a much cheaper rate than in the city. This can only be done *by a considerable remission in the present Government building fines and land taxes, by opening up agricultural areas for building purposes to the intending occupiers, and by running a cheap, rapid and frequent railway service to and from the city.*

But such building schemes can only help the middle and the lower middle classes, who find employment as salesmen, etc., in shops, or as clerks, etc., in the large mercantile and Government offices in the City. *They cannot be availed of by, and would not therefore materially help, the artisan and industrial classes* such as the mill-hands, or those who find employment in other local factories and industries. Neither would they benefit the purely *labouring classes* who earn their livelihood by working as labourers on the railways, wharves, docks, and shipping in the harbour, or as coolies on roads, buildings, bazaars, etc., all over the city. They would naturally find it a difficult matter to live out at a considerable distance away from the principal centres of their employment. Nor would it suit the more easy and luxurious needs of the rich people, who would naturally prefer to live in town, in the most fashionable and healthy parts, such, for instance, as Colaba, the Esplanade, and Malabar Hill, having the means to do so at their command. Of these latter we will speak later on.

The needs of the middle and the lower middle classes could be further met by developing the Mahim area, and rapidly completing the Improvement scheme for the *intermediate area comprising the north-eastern portions of the city beyond Parel. Further development might be effected, with the increasing needs and the expansion of the city's population, towards Salsette,* which is bound to be a large and healthy suburb of Bombay at no distant date.

C. For the mill-hands and the artisan classes, however, a special effort to provide for them *a sufficiently large number of sanitary chawls* must be made by the millowners and other large employers of labour, themselves. There has been considerable talk, for the last five years and more, of providing the mill employés and the industrial classes with suitable chawls on the mill premises or near business quarters. But, beyond the talking stage, no tangible result has yet been arrived at. It scarcely requires to be reiterated, however, that it would ultimately be to the profit of the millowners and other employers of labour, themselves, to lodge their employés in such sanitary chawls within or close to their business premises.

With the idea of giving some measure of relief to this overcrowding amongst the poorest classes, one or two schemes, partly based upon a kind of quasi-philanthropic basis and partly upon business principles, were considered about five years ago by certain millowners. It was hoped that, with the co-operation and monetary support of a special character from the Improvement Trust and the Government, some tangible results would be achieved in the near future. The schemes were actively discussed for a while in the local press with all the warmth and vigour of first impulses, papers were read, and letters written as usual. But public interest in them waned as rapidly as it had waked up, and the whole thing fizzled away and died out within a few months into the limbo of oblivion.

Even with regard to our mill-hands, only a few mills, not more than half a dozen, we believe, out of nearly ninety in our city, have hitherto provided such workmen's quarters for their own employés. Surely it is high time in the interests of all concerned, both the masters and the men, that the millowners and the shareholders in mills should wake up to their responsibilities in this matter, and take an early initiative.

D. Some people advocate the *building of sanitary chawls for the poor by unaided private enterprise.* They wish to see established *Building Societies,* to work partly on a semi-philanthropic and partly on a commercial basis. It is to be feared, however, that, unlike Great Britain and the Continent, they may not prove generally successful out here and that they would result in a

certain amount of loss on their venture in the long run. Such an effort has already been made in our city by the Parsi community, by the foundation of what is known as the "*Zoroastrian Building Society.*" But their experiences, so far, have not been very encouraging. This Society is to a certain extent worked on semi-philanthropic lines, inasmuch as its shareholders have agreed to accept only 4 per cent. interest on their invested capital. And yet it is being already found in the very first year of its working, that, on account of the present dearness of labour and material, and the consequent increased capital outlay, the rent from their buildings will not quite realise a nett earning of 4 per cent. after deducting all expenses, unless the rent be comparatively high for the class of people for whom they are mostly intended. To meet this deficit, the Society has been obliged to supplement its earnings by inviting voluntary subscriptions from the Parsi community, to found a sort of a permanent charity fund to enable them to meet the loss resulting from renting their rooms at very moderate rents to the very poor of the community. The prices of land, and of building materials and labour have ruled so very high in Bombay, for the last few years, that in order to realise even 4 per cent. on the invested capital the board of directors of this Society would be obliged to charge rents ranging from Rs. 15 to Rs. 20 for a set of two moderate sized rooms and a kitchen, on the lower and upper floors, respectively. Even this rent, the poor class of Parsis, for whom these buildings are intended, can scarcely afford to pay. The board is obliged therefore to let them out at rents varying from Rs. 6 to Rs. 12 per month according to circumstances, and the loss which thus accrues is met out of the Charity Fund. With such an object-lesson before them, it would not be surprising if private enterprise and private capital should look askance at any such schemes brought forward for their voluntary support and co-operation, unless and until some of our large-hearted capitalists and large employers of labour combine, and jointly undertake to launch such a scheme even at a certain personal sacrifice, and as a matter of duty they owe to the city and to their poor employés who have given them, so to say, their present position, prosperity, and affluence.

E. But if there is a special call of duty on the philanthropic citizens of Bombay in this important matter affecting the health and even the lives of their poorer brethren, *the call is none the less urgent on the Government of Bombay,* as the custodians of the well being of the dumb millions placed by a divine Providence under their charge, to do all they possibly can to ameliorate, as far as possible, their present wretched condition. *They must not only help private efforts by substantial concessions in the matter of raising loans on easy terms, but must make provision for liberal Budget grants for the housing of the poor, and for the improvement of the city* generally, on the same liberal scale as has been already done by the Government of India for Calcutta. Nor is this *call of duty* less imperative *on the City Improvement Trust,* which is specifically created with the set purpose of improving the city's health conditions generally by, among other things, *demolishing the slums and largely creating in their place healthy sanitary quarters.* What they have done in this direction is little compared to what they have still to do. For their duty, towards the poorer classes specially, does not begin and end with the provision of a couple of dozen chawls to accommodate a few thousand people. They should be given a freer hand and larger powers to enable them to give a reasonable quota of help in all undertakings for the special benefit of the poor, without the constant dread of going beyond their legal limits and liabilities. The *Bombay Municipal Corporation is another body from which the public naturally expect a good share in this direction.* But we believe the full two per cent. that they furnish annually to the coffers of the Improvement Trust, which translated into figures would amount to about half a million rupees every year, may reasonably be considered for the present their fair share in this work of improvement. Bodies like the *Port Trust, the G. I. P. and the B. B. & C. I. Railways also owe an obligation and a duty to the city* and can help considerably, if they choose to do so. But we are sorry to say they have failed to do so, so far, and have sheltered themselves behind the inadequate excuses that such help does not come within their legal liabilities, and that their legal powers do not permit them to do it. But we hope that their legal liabilities may be somewhat enlarged in this direction, so that they may soon wake up or be made to wake up to a full sense of their responsibilities.

F. Fresh legislation by Government, to somewhat amend the present Municipal Act, as well as the Improvement Trust Act, and to thus strengthen the hands of both these bodies, is also necessary. It must be so enacted as not to press unduly hard upon the parties affected by it, and yet considerably help these two bodies in enforcing certain essential sanitary measures on landlords. Such legislation may perhaps be considered somewhat of a hardship by some people. But it is bound in the long run to prove beneficial to both landlord and tenant. These legislative measures may, for instance, include *powers to the Improvement Trust,* (*a*) to acquire sites anywhere in the city, or outside it, to enable dwellings to be erected for the labouring and working classes, (*b*) to exercise a controlling influence on overcrowding, by enabling them to limit the number of houses on available areas, as well as the proportion of the area of a building plot that may be built over by the owner, and prohibit building on a plot of less than a fixed minimum area, and (*c*) to advance loans on fairly favourable terms and under proper guarantees, to private syndicates of well-known and respectable individuals, for building purposes. There is some difference of opinion, however, as to the desirability of thus advancing loans on easy terms to large millowners and capitalists who could very well take care of themselves but would not.

Greater powers might also be extended *to the Municipality,*—(*a*) *to exercise a more efficient control on*

building operations generally, during the erection and alignment of new buildings, or during structural alterations in old and rickety ones, by private house-owners. A committee of the Corporation is revising the existing Building Bye-laws, and we trust the revised bye-laws will, without pressing unnecessarily harshly on landlords, be more stringent and effective in giving to the long suffering tenants greater safety from jerry buildings, more room to breathe and move in, and more of God's air and light and sunshine than at present; (*b*) powers *to appoint Sanitary House Inspectors* should also be given to the Municipal Executive, with the object of enforcing on the tenants as well as the landlords greater cleanliness and less overcrowding on their premises, and of instructing the ignorant inmates of houses in the first principles of sanitation in general, and personal hygiene in particular, and inculcating in them the all-important habits of cleanliness; (*c*) Legislation may also be directed towards *assessing the value of building sites* rather than assessing on the rental of buildings erected on them.

Government may also beneficially *modify the present extremely heavy building fines*, enforced in some of the suburbs in close proximity to Bombay on the somewhat hollow plea of conserving land for purely agricultural purposes. This naturally stifles all building enterprise by private individuals. They must also somewhat *modify* the present system of revising the valuation of Government lands, and the heavy and somewhat *capricious enhancement of assessment at every such re-valuation.* The rates levied on newly assessed Government lands appropriated for beneficial purposes have been enhanced in some cases ten times over the sum levied on them only five years ago. The natural effect must be to make them absolutely prohibitive for buildings for the middle and the lower middle classes of the city.

G. Strict restrictions should be placed in future on the appropriation *of all available land* in the city, or in its close vicinity, *for the building of spinning mills*, or *large factories*, or *warehouses and workshops* for industries of various kinds. The *railways* especially should now be strictly *prevented from* taking up any more lands for *establishing large yards*, or for carriage and waggon factories in close proximity to the city. They are enough of a nuisance as they are, and it would be simply intolerable if they were allowed to occupy land for such a purpose, or to encroach any more upon fresh pieces of land most badly wanted to relieve overcrowding in the city, the more so, as they stand selfishly aloof from all help to the city's poor. Whenever possible the *mill and other industries* might be *gradually shifted* from their present sites within the city, and located *in areas further north*, on its outskirts. Along with their removal the mill population of the city would naturally tend to migrate to the sanitary residential quarters that may be provided for them by the millowners on their own properties, or by private builders in their close proximity. This would automatically relieve overcrowding in the long run to the extent of about a lakh of people, if not more, or about one-tenth of the entire population of the city.

H. Further reclamation and filling in of low-lying lands north of Haines, DeLisle and Fergusson Roads, &c., would also necessarily afford considerable relief to overcrowding, by providing a large number of people with accommodation in the houses and tenement chawls that might be built upon these reclaimed areas. The Improvement Trust have already notified an improvement scheme with regard to developing some of these areas of low-lying lands north of Haines Road. There are, however, other large *areas of vacant land in Mazagon and round about Parel* which would *afford good building sites*, and the scheme for opening up land west of the old Government House, Parel, and extending operations on to Vincent Road and Dadar, has already been notified. But, as regards the possession and development of the "Flats," the matter is still under discussion between the Corporation and Government. It is very much to be wished that they may soon pass into the hands of the former for further development.

I. So far we have concerned ourselves with the middle and poor classes. But *the wealthier class*, as a part of the city's population, *have also a right* to expect some consideration *in any schemes for the relief of overcrowding*, and the provision of better house accommodation. It is true they occupy at present the most healthily situated portions of the city, such as Malabar and Cumballa Hills, &c. But what they have is perhaps not enough for their daily increasing need for more elbow room and greater ease and comfort. Hence it is desirable to consider in what direction they can be best met. And the principal and most natural line of expansion for these classes is the extension of their *residential quarters along* the magnificent *western foreshore of Bombay*, beautifully situated and open to the sea breezes, and extending from Malabar Hill along Mahalaxmi to Worli, and right up to Mahim. But it must, in the first instance, be rendered habitable by the removal of the Pumping Plant and Sewage Outfall from their present location at Love Grove, further on to Worli, or still further north and east to Deonar. In their recent reply to Government on the subject of the development, &c., of Bombay, the Bombay Corporation rightly say: "For the middle and the more well-to-do classes, the Improvement Trust Schemes (Nos. V and VI) and the vacant lands of Mahim and Dharavi will afford the most suitable and convenient areas, and the immigration of these classes will entail also that of considerable numbers of domestic servants, shop-keepers, labourers and artizans."

J. But there is yet another important factor which requires to be seriously considered. And that is the *construction of adequate roadways, or channels of communication*, between the different parts of the city and the outlying suburbs, so as to make them easily and rapidly accessible by *means of an electrified system of train or tram service.* Whether the present western seashore route of the B. B. & C. I. Railway, from Grant Road to Colaba, is to be retained, or modified, or abolished altogether, whether all the passenger and goods traffic should be concentrated along the eastern route of the G. I. P., and the new Port Trust

Railway lines, and whether an overland route, with an electrification of the present B. B. & C. I. suburban line extending up to the Victoria Terminus, should be substituted, are all economic questions for the careful consideration of the authorities concerned. But, in doing so, they must take into account the facilities that should be given to the people residing in the suburbs, and meet their wishes as much as possible, in order to encourage them to live out of town. In any scheme or schemes for such a *transit by rail or tram*, one thing must necessarily be borne in mind, and that is the *provision of a rapid, frequent and cheap service*, so as to economise time in travelling as much as possible, and not press even in a small degree on the very slender means of the poorer classes. *Cheap workmen's trains and trams* might be introduced in the working of such a scheme with considerable advantage.

As regards the *remedial measures for Causes Nos.* 2 *and* 3, we have discussed them both at some length in another paper also contributed to this Section of the Congress, and we will not therefore go over the same ground again here.

Causes Nos. 4 *and* 5.

(4) An *intermittent*, *irregular*, and *insufficient supply of water for domestic purposes*, and

(5) The *enormous waste of this water supply* from various causes, including *leakages from Bhandarwada and Malabar Hill Reservoirs.*

With regard to these, we think it would be preferable to consider both of them together, because they both refer to common defects in the water supply of our city. *The remedies* for these can be summed up, for all practical purposes, in two sentences, *viz.*, (1) a carefully regulated scheme for a *constant supply* with an *even distribution of water* sufficient *for domestic purposes* all over the city, and (2) a *stoppage of the enormous waste both under and above ground by means of Deacon's Meters, and the inspection and supervision over the daily supply* by a properly organised inspecting staff controlled by a specially trained and experienced water engineer.

At present there are *two distinct proposals* before the Corporation and the public. (*a*) One is to organise *measures to stop the enormous underground waste* from leaky underground water pipes and mains, and from the two reservoirs, as well as *to stop the waste* entailed in houses *by careless domestic consumption and leaky water taps.* (*b*) *The other* is to bring more water in to the city *by a duplication of the Tansa mains.*

(*a*) Almost all of this combined waste, to the extent of from 10 to 15 million gallons per diem, is said to be preventable by properly concerted measures under a well organised inspecting service. This would certainly save to the city about 8 to 10 million gallons at least of water daily, and it could be utilized towards making the present water supply almost constant. The cost of making this large saving in water would be very little compared to that of the second proposal. In either of these proposals, however, some of the old and worn out pipes and mains will have to be replaced by new ones, and all corroded and leaky water pipes, and all the street mains under 5 or 6 inches in diameter, will have to be replaced by new ones of a somewhat larger calibre to ensure a good supply at high pressure.

(*b*) The second proposal before the Corporation is to have *a duplication of the Tansa Water mains.* The cost of such a large undertaking would be almost prohibitive, entailing an expenditure of fully 60 lakhs of rupees, if not more. It certainly is very desirable to give a larger supply of water per head of the population than is actually received at present. And the duplication of the Tansa Mains would no doubt be effective in fulfilling this object. But it is the opinion of many, that, before such an extremely expensive scheme is undertaken, a very careful enquiry should be first carried out to ascertain if it is not possible to increase the city's water supply by saving up the greater portion of the present waste, and utilising it towards a more efficient and more constant service. It should also be ascertained whether the present carrying capacity of our sewers and drains would be equal to the very heavy demand that would necessarily be made on it if the duplication of the Tansa mains is carried out as suggested. A much larger quantity of waste water than at present would necessarily be returned into the sewers and drains than they could possibly carry to the outfall in their present more or less surcharged condition. Some other large engineering works would therefore also be needed in addition to the duplication of the mains, costing several more lakhs of rupees, to sufficiently increase their present carrying capacity, before we can think of any duplication of the Tansa mains with equanimity. A large portion of this additional quantity of water brought into the city from Tansa, and calculated at about 20 million gallons, would probably find its way into the sewers, and could certainly be carried off by enlarging their carrying capacity as stated above. But a considerable quantity must still soak into the soil and would require to be carried off, perhaps, by means of fresh surface and subsoil drainage works specially designed after the manner of the surface and low level channels planned by Mr. Santo Crimp, and this would also mean additional expenditure.

But whatever the quantity of the daily supply per head, *the purity of the supply* is another important factor which cannot be neglected. At present the comparatively pure Vehar, and the much purer Tansa, water is greatly contaminated by the admixture of the very impure and at times unfiltered Tulsi supply. This admixture is necessitated by the fact of the quantity of water received into the city from the first two lakes not being enough, especially during the warm weather. *It is said that, for a large number of days in the year the water that is supplied is not all filtered*, and as a consequence there is the ever present danger of a wholesale contamination and an outbreak of any water-borne disease at any time in the city. This must be very carefully guarded against. In any provision, therefore, for an increased water supply to the city, *provision must also be made for its proper filtration* on a larger scale than at present,

which of course means still further expenditure. Again, for the general adoption and better working of the water carriage system in the city, it is also very necessary that the *service of a constant and a larger supply of water than at present should be expedited as quickly as possible*. And unless this is done, the present loathsome halalkhore system and its attendant evils cannot be abolished from our midst. The use of sea water to flush and clean our drains and sewers has been now and again recommended on the ground of its use being more economical, and possibly somewhat disinfecting. But opinions vary considerably as to the advisability of its adoption.

Another important advantage of *a constant supply* would be that, besides improving the city's general cleanliness, it *will indirectly prevent the present enormous waste of water occurring during the course of domestic consumption*. For people will not then leave their taps open all day and night, as at present, because of the consciousness that they will get their water whenever it is wanted.

Causes Nos. 6, 7 *and* 8, *viz.*—

(6) *Pollution of the surface of the soil and pollution* and *saturation of the subsoil* with sewage and other impurities, and *their imperfect drainage*.

(7) *Incomplete* and *faulty storm and surface water drainage*, and the consequent *bad subsoil drainage*, and *high level of subsoil water*.

(8) The *existence of certain low-lying lands and swamps* in close proximity to the city, known as the "*Flats*," the depositing on these of "kutchra," or refuse, and *their incomplete drainage*.

The remedial measures for these causes may be grouped together under one head. It is generally recognised that the one measure that is most urgently needed to remedy them to a greater extent than at present, is to have *an efficient system of disposal of their surface water, and an indirect drainage of the subsoil* by means of special high and low level surface channels. In his report made in 1899, *Mr. Santo Crimp recommended*, in the first instance, the *immediate construction of the two low level channels* known as *channels Nos. 1 and 2, with a main channel, and some side channels and sluices*, in order to draw and dispose of all the storm and other surface water of the low-lying districts of the city directly into the sea. These channels would, in his opinion, be able to drain the existing swamps in the interior of the Island, and be also able, in conjunction with a new storm water drain in Tardeo Road, to receive and draw away the waters from the suburban high level areas for some years longer. With the steady increase in the population *a few years hence*, however, *high level channels* would be soon *necessary* to relieve the increasing pressure on the low level channels, and should then be taken in hand. The low level works must however be, in his opinion, large enough to meet the requirements of the high level areas for some years. The *low level channel No. 1* has been now *completed* for some-time past, and *No. 2 low level channel*, as well as the *new Tardeo drain*, have been also under construction, and are *almost completed*. But we humbly submit that it is time that the high level channels, as well as the *sewerage and drainage of the unsewered district in the northern part of the Island*, were taken in hand, and the sewage made *to flow to a new pumping station in the north* and be discharged into the sea *by a separate outfall at Worlee Point*, as recommended by Mr. Santo Crimp. He says that, if the surface waters are thus properly drained and disposed of, and "the surface dried by suitable channels, and the liquid surface and subsoil pollution prevented, then the subsoil will take care of itself." According to him the soil of Bombay generally being clayey, and clay being extremely retentive of moisture, with a small free water capacity, deep subsoil drainage cannot be resorted to, as the water would not flow to the channels, and it would not be as effective as surface drainage, and is not, therefore, the proper remedy. Besides the above measures, he had also recommended the *abolition of the old storm water Reservoir at Mahalaxmi*, which was a source of great danger and nuisance. This was to be effected by the construction of a "Bund" alongside the course of the main storm water drain, from Clerk Road to Worli sluices, by which the amount of storage required in times of severe storms, during the Monsoon, would be diminished by one-half, without flooding the surrounding lands, and would thus enable the Mahalaxmi Reservoir to be abandoned. He recommended also that the best means of keeping the surface dry consists in the *cementing and "Ovoiding" of the gullies and side channels*, and other conduits of sullage. To speak in his own words, "Water-proofing should be resorted to in every case where sullage water is discharged or conveyed, whether it be a washing place, a gully or any other channel. From the moment the sewage leaves a building, it should be conveyed to the sea by means of an impervious channel." Theoretically, this is excellent advice. But, practically, we are afraid, it has been more observed in its breach than in its exercise. It must be said, however, that an effort has been made by the Municipal Executive, within recent years, to enforce this cementing on all house owners with regard to their house gullies.

Cause No. 9.—The existence of a large number of tanks and wells in a bad state of conservancy, of quarry holes, irregular hollows and broken up *plots of low-lying ground, badly drained* and in close proximity to populous districts. Also the *new Dock works, entailing large excavations* over a wide area to the east of the city.

With regard to this, we have already discussed the danger and the nuisance generally lurking in them. It is one of the duties of the Public Health Department to see that all the public tanks and wells vested in them are kept clean, and free from rank vegetation, and prevented from being contaminated by outside pollution. To do this *they should be cleaned periodically* by a special small tank-conservancy staff. Spasmodic efforts have been made, it is true, to get a few of the larger tanks

cleaned now and again, but thoroughly emptied and cleaned they have scarcely been even once in all their existence. The expenditure incurred in these cleaning operations has perhaps been a deterrent to Municipal activity in this direction, and people have suffered in consequence. We submit that this periodical cleaning should be done in all cases as a matter of public necessity, failing which, only the tanks and wells should be closed as a last resort.

The Municipal Executive's tendency, unfortunately, has been in the direction of filling up these tanks and wells, both private and public, wherever it can be enforced. This entails less trouble, and is perhaps more economical for the Municipal Exchequer in the long run. In the case of private wells, however, it might be reasonably urged that instead of condemning them wholesale, and absolutely filling them up, the owners should be asked to clean them properly. At the same time it is incumbent on the Municipality to see that their own sewers and drains, which are the true sources of contamination, be kept water-tight and not allowed to leak, by proper inspection and repairs.

With regard to the large number of *irregular hollows* and broken up pieces of waste land, *and shallow pools* of water, which constitute a fruitful soil for the breeding of malarial mosquitoes all over the city, common sense tells us that they *must be filled up as fast as possible*. The teaching and experience of science all over the world, acquired by the discovery of the Mosquito theory of malaria, tells us that they constitute the indirect cause of the origin and spread of malarial fevers. It is, therefore, imperative on our Municipality to organise an active and systematic campaign against the present violent epidemic outbreaks of malarial fevers in all parts of the city, outbreaks which have already become endemic in some parts, especially in Fort North, and at Mazagon. With this object a specially trained staff for *a sustained and vigorous malarial campaign should be organised*, under experienced and capable direction, to supervise the work of the gangs of coolies under them, and to *make a house-to-house visitation, and inspection of the premises and the surroundings of houses*, and take measures suited to each house or locality. Of course all these measures against malaria are now widely known, and have been acted upon in our city, but somewhat spasmodically. What is really wanted is a well organised and sustained effort to completely eradicate the haunts of these mosquito pests. A much larger number of cooly gangs must be employed to do the filling in operations, wherever necessary, quickly, to use kerosene oil to fill up hollows in certain trees, to remove all rank vegetation and broken and empty tins, pots, etc. (in which these mosquitoes generally breed) from the house premises, and from their neighbourhood. Last but not the least, it is very necessary *to instruct people in the first principles of personal hygienic, and house sanitation and cleanliness*. The *adoption of the mosquito curtain* wherever people can afford its use, and a *liberal distribution of quinine as prophylactic*, are also very necessary measures. Of course all these measures are well known, and are merely repeated here with the object of insisting on their active and systematic adoption, so as to nip in the bud a scourge which may hereafter prove more intractable and troublesome than even the plague. A wholesome agitation with regard to the recent malarial outbreaks in Frere Road, started a few months ago in the Corporation and in the local newspapers, has had the excellent effect of waking up the Municipal Executive and the Government, and the latter have already appointed a mixed committee, representing the various interests of the city, to investigate the whole question of malaria, and suggest suitable remedies. Let us hope that their report will be issued at an early date.

Cause No. 10.—This relates to the *extremely insanitary condition of most of our public stables, and especially milch stables*, which are notorious for their sickening interior and filthy exterior, *and their improper and dangerous location*, shoulder to shoulder with the houses of the poorer classes, in the most congested quarters of the city. We have already discussed their great danger to public health on account of this close proximity. And, for that reason alone, if for no other, it is incumbent upon the authorities to enforce as stringent measures with regard to their sanitary condition, as they do, for instance, in the case of the building bye-laws, or sections of the revised Municipal Act with regard to the erection or repairs of buildings or construction of drains, water closets, house connections, etc. We have already alluded to the report of the Committee of the Corporation appointed to investigate this subject, in which great laxity and astonishing irregularity, on the part of certain Municipal Departments, have been very clearly exposed. To remedy such a state of affairs, as well as to considerably abate the nuisance, the Committee have made certain recommendations for the consideration and early action of the Municipal executive. These are good in themselves no doubt. But, to get the full benefit out of them, we humbly suggest that it is absolutely necessary that a *more vigilant stable inspecting staff than at present should be organised*, who should be required *to pay frequent surprise visits to all the public horse and cattle stables* in the city, and especially the *milch stables*, and see that they are kept clean and free from overcrowding, and are well paved and properly drained, according to strict Municipal requirements. Not only the milch stables, but *all the dairies as well* as places where cattle are milked, or milk is stored temporarily, *should be under strict supervision, and placed under proper sanitary conditions* to ensure as pure and wholesome a supply of milk as possible. Periodic surprise visits should also be given by the superior officer in charge of the License Department, as well as by the Executive Health Officer himself occasionally, so as to keep the whole minor staff on the *qui vive*, and alert in their inspection work. In our humble opinion, there is not enough outdoor supervision and inspection on the part of the superior and lower grade officers, as well as the heads of almost all Municipal Departments over their men, and, for want of such a wholesome check on their subordinates, efficiency in the execution of the

duties of their minor staff necessarily becomes lax, and suffers considerably in consequence.

But the *great danger of these stables* lies in their *being located in the very heart of the city*, and in the most crowded localities. The real solution of the danger, therefore, lies in their *removal from their present sites*, within the city, to other more suitable ones in a freer atmosphere, *outside its precincts.* This problem of their proper location is, it must be confessed, many sided, involving various interests, and one, therefore, which cannot be easily solved, and requires united action on the part of the various bodies concerned. One of the recommendations of the Committee already referred to was that the Municipality should either erect stables at their own cost, and charge just sufficient rent to recoup expenditure, or that they should prepare suitable sites for the erection of stables, and lease them by auction. In discussing these suggestions, the Municipal Commissioner, in his letter to the Corporation, dated the 2nd October, 1907, says, "As regards the first suggestion, it is pointed out to me that the erection of such stables will involve a heavy outlay and the appointment of a greatly increased staff, and that such expenditure seems hardly justifiable so long as the present staff and the Health Department bullocks remain as at present without any accommodation whatever. It appears preferable at the present juncture to leave the erection of milch stables to private enterprise, and confine our activities to supervise their sanitary conditions. As regards the alternative proposal to prepare sites and lease them by auction, according to a letter received from the City Improvement Trust, it is the intention of the Chairman of that body to suggest to the Trustees the setting apart of some 30,000 square yards of land for this purpose out of the proposed East Agripada scheme, the idea being to have plans for stables prepared, and lease plots for building according to these plans, and under stringent regulations. This being so, it seems advisable that the Municipality should defer action until the East Agripada scheme has been adopted, and should confine itself as at present to discouraging the erection of stables in thickly populated parts of the city. Apart from any arrangement which the City Improvement Trustees may hereafter make, it will not, in my opinion, prove an impossible task for the Municipality to gradually relegate milch cattle stables to the F and G Wards." We quite agree with the Municipal Commissioner in thinking that the real solution of the difficulty lies in shifting the milch stables to the outer and less crowded precincts of the city, where they might be built under better hygienic conditions and on a more open and sparsely populated land, and where better facilities might be obtained for pasturage and milking and also for better inspection and stricter supervision. At present the enormous *milk supply of Bombay is not merely derived from* what is obtainable from *the milch stables in the city*, for it will scarcely suffice for even a portion of the city's population. A *considerable quantity* is even now *brought in by rail* from such places as Bandora, Thana, and even from distant Kalyan. If, therefore, the milch stables are removed to the suburbs, *arrangements* might be easily made with the railway companies *to bring up fresh daily supplies by special milk trains.* But it must also be borne in mind that it is not wise to altogether drive away all the milch stables out of town to distant parts of the Island, because the milk supply would not then be as cheap comparatively speaking and as easily accessible to the people as now, owing to the want of sufficiently rapid means of transit, and the comparative increase in the cost of such transit and its subsequent distribution. A few milch stables might therefore be allowed to be located under strict Municipal supervision in the East Agripada estate, or on some suitable sites in the Parel and Byculla districts. These are, however, details which can be easily settled. And it is probable that the present more rigorous enforcement of the Municipal Bye-laws with regard to these milch stables, by the Municipal Executive, and the difficulty of getting fresh suitable sites within the city at a reasonable rental, will have the desired result of slowly, but surely, causing the gradual transference of these stables towards the north of the Island.

With regard to *the public horse and bullock stables*, the problem of their location is not so easily solved. In the first place it is the opinion of the Municipal Solicitors that the Bye-laws relating to these stables are *ultra vires.* Then again certain sections of the Municipal Act being unworkable, cannot be properly enforced by a Magistrate and, therefore, require amendment. But the most important point for consideration in this connection is the great difficulty on the part of the owners of hack victorias and bullock carts to find accommodation for their vehicles and animals in close proximity to the business quarters of the town. This can be readily seen from a petition by these men to the Corporation in December 1906, in which their difficulties were set forth very forcibly. According to this there were about 8,500 carts and 17,000 pairs of bullocks located in different parts of the city owned by men with small means, and mostly utilised for the transit of cotton goods and other commodities of merchandise and labour products in the city. Such are generally located in unlicensed stables, under "Jowlee" sheds, on vacant plots of land wherever available. In fact it is very difficult, almost impossible, for these small owners to get suitable sites for licensed stables within reasonable rent, and no capitalist will care to build stables for them even if occasional sites are available. The only solution lies in the provision of suitable accommodation for them by the Improvment Trust.

Cause No. 11.—The last, but by no means the least important of the causes of the bad hygienic condition of the city, is, *the peculiar social customs, habits, and prejudices of the people, and their dense ignorance with regard to even the first principles of sanitation.* And because of this dense ignorance of the oriental people, it has been the fashion to say, of late, that

"East is East and West is West." But in the continuous onward march of civilisation, and the steady progress of science, *East is not always East, and West cannot be always West.* They *must* go hand in hand, must exchange and interchange, and the East must then be West, and the West East, in the noble and common cause of the advancement of the human race. The West will thus unconsciously repay to the East a portion of the accumulated debt of ages owed by it through the centuries long gone by, when the West was steeped in deep darkness and ignorance, and the East was already resplendent with civilisation. It cannot be denied, however, that, notwithstanding a certain progress, the habits of the poorer classes of the population here, as everywhere else more or less, still remain very uncleanly, and there is a considerable amount of filth and squalor in their midst, both within and without their dwellings. Owing to these factors, a large amount of disease and illness prevails amongst them, and, what is perhaps of equal importance, by the continued and accumulative effects of these, their energy for work is greatly diminished, and their vitality for resistance to attacks of diseases considerably lowered. It need hardly be said that this diminution in their working capacity is not only a great loss to themselves, but a serious pecuniary loss to the various industries of the city, and an economic loss to its general commercial prosperity. All this could be considerably lessened, if only the poorer classes could be made to understand and appreciate the value, and observe the first principles of personal, hygienic, and household sanitation. This can only be done by the constant exercise and impression of certain corrective and educating influences on them. And the best way perhaps to do it is, (1) *to institute a house-to-house visitation of trained instructors by the Municipality,* whose chief business would be to find out the chief insanitary conditions in the people's dwellings, and point out to them in a simple kindly manner the ways and means of removing them, and (2) *to give Free Primary Education* to the masses at the expense of the Municipality, if compulsory education is not possible just yet. No amount of expenditure upon greater cleanliness and better sanitary provisions can ever compare with, or come up in point of good results to, the advantages thus accruing to the people from a liberal spread of free primary education amongst their children, and the inculcation of a clearer conception in them of the advantages of household cleanliness, and the blessings of good health resulting from such sanitary surroundings. All this may seem mere platitudes, but, all the same, they haven't been put in practice yet, and it is with the object of attracting greater attention to them that we have referred to them here in detail. The question of a Free Primary Education to the city's poor has been only quite recently under the consideration of a Committee appointed by Government some time ago. Their report is now before the Corporation for discussion. The Committee is not in favour of a compulsory education, because in their opinion the time has not yet arrived for it. They are not over enthusiastic, either, in favour of a scheme for a Free Primary Education, yet they have made certain valuable suggestions in that direction. It is to be hoped that both the Corporation and the Government will meet them in the most liberal spirit, and that, by mutual co-operation, the recommendations and suggestions of the Committee will be carried further forward in the near future, beyond the limits to which they have seen the necessity of confining themselves for the present.

To briefly recapitulate the remedial measures discussed above, they are —

(1) Early provision by the Improvement Trust of a larger number of sanitary chawls or tenement houses, than at present, built in different parts of the city, with special reference to the density of the population and the number of people displaced by the demolishing operations of the Trust.

(2) A quicker opening up and expansion of the suburbs, to the north of the city, by the Improvement Trust.

(3) Greater facilities for cheap and rapid transit to and from the suburbs to the city, by rail and tram. Also provision of special workmen's trains.

(4) Provision of a number of open air areas in the most thickly populated parts, to serve as "lungs" to the city, as well as for recreation purposes.

(5) Careful survey and thorough examination of the storm water drains, and a more expeditious improvement of the chief defects still existing in our present sewerage system, on the lines already suggested by experts.

(6) A rapid completion of house connections to enable the proper working of the water carriage system, and till then, a more frequent and efficient cleaning and flushing of sewers and drains than at present. Also a systematic periodical examination of the inspection chambers placed on house drains.

(7) An early extension of the present outfall further north to Worli Point, and a rapid completion of the schemes for the sewage disposal of the unsewered districts, with the provision of a new outfall for them. Meanwhile, the temporary employment of a larger minor staff for the Halalkhore service, and an early provision of improved pails instead of the present nightsoil baskets.

(8) A more rapid completion of the proper paving and channeling of house gullies.

(9) An early completion of the measures suggested by the sanitary experts for the proper drainage and disposal of surface and storm water of all the districts, and a proper drainage of the Flats.

(10) Placing the entire conservancy of the city including the sewer and drain cleaning

operations, under the sole control of the Health Department.

(11) Immediate carting away of street sweepings and gully refuse by means of motor cars or Renard trains, morning and evening, or oftener, instead of allowing such to accumulate to overflowing on the dust bins, for some hours before removal, as at present.

(12) Proper location and a very careful supervision of the milch and other public stables, and a vigilant supervision over the milk supply of the city, and its storage.

(13) Immediate filling in of such tanks and wells as cannot be satisfactorily improved even by careful cleaning, and their conversion into open play grounds and gardens, when large enough for that purpose.

(14) Filling in of broken and irregular plots of ground and pools of water, wherever found, and destruction of mosquitoes by a liberal use of kerosene oil wherever necessary.

(15) A carefully regulated but continuous water supply in all parts of the city.

(16) Rapid completion of measures to stop the leakages from the Malabar Hill and Bhandarwada Reservoirs, as well as from the underground leaky water mains.

(17) Introduction, on a larger scale, of Free Primary Education, to begin with, amongst the poor of the city, side by side with the introduction of an elementary knowledge of the first principles of sanitation, through the agency of the Health Department, and of Municipal and other Primary schools in the city.

(18) Provision of some public bathing and washing places in poor and thickly populated districts, to enable the poor to keep their bodies and clothes clean, and to also indirectly help in diminishing the saturation of the soil by preventing the public stand pipes being used for these purposes, as at present.

And now before we conclude this paper, we will beg leave to say that we are fully conscious of its many shortcomings and perhaps some inaccuracies also. We must also apologise for its great length, and the somewhat superficial treatment of some important questions. But our excuse is, that the subject matter itself of the paper is a very large and comprehensive one, including, as it does within its scope, various important matters vitally affecting the health and well being of the city's population. We will also frankly admit that, as in the causes so also in the measures necessary for their prevention and removal, we have not suggested anything that is new or original, for most of these remedial measures are almost self-evident to any one who cares to study the various factors constituting the present unhygienic conditions of our city. All that we have been able to do in this paper, therefore, is

APPENDIX A, TABLE No. 1.

Table showing the Population, according to the latest Census Returns available, Death-rate per mille for the quinquennial period last preceding it, Area, Annual Income and Annual Expenditure on Health Department of the Municipalities, and the average rates of that expenditure to Income, of Indian Presidency Towns, and of London, Manchester, Liverpool and Glasgow.

Municipalities.	Population.	Average death rate per mille for the quinquennial period preceding the Census.	Area in Acres.	Annual Income (in Silver).	Annual expenditure of Public Health Department (in Silver).	Average ratio of Health Department Expenditure to Income.
				Rs.	Rs.	
Bombay	977,822 (1906)	64·13	14,385	96,48,500 (1906-07) 95,89,324 (1907-08)	21,10,094 (1906-07) 22,87,706 (1907-08)	1 to 4·5 1 to 4·3
Calcutta	847,796 (1901)	* 31·1	23,908	(Not available for 1901). 70,96,984 (1906-07)	2,03,708 (1906-07)	1 to 7·9
Madras	509,346 (1901)	† 40·4 (1891) 44·8 (1901)	17,280 (1891) 17,564 (1901)	(Not available for 1901). 33,28,824 (1906-07)	3,28,381 (1906-07)	1 to 10·4
London (City and County).	4,536,541 (1901)	19·	74,839	6,36,79,650 (1901-02) 13,13,36,295 (1906-07)	12,48,690 (1901-02) 15,53,130 (1906-07)	1 to 51 1 to 84·5
Manchester	637,520 (1906)	20·14	19,059	2,81,36,460 (1906-07)	46,34,3[illegible]0 (1906-07) 28,91,640 (1901-02) without hospitals	1 to 6
Liverpool	680,000 (1901)	28·1	13,236	....	23,36,730 (without hospitals)	1 to 4·5
Glasgow	781,000 (1901) 900,000 (1896) (Not available for 1906.)	19·4	12,688 (1901) 11,861 (1891)	2,76,10,375 1,29,32,235 (1901).	19,87,065 21,58,455 (in 1901)	1 to 13·5 1 to 6 (in 1901)

* Calculated on the Census of 1901.

† Calculated on the Census of 1891 when the population was 452,518.

simply to pick out certain prominent defects in our sanitation, to direct to them the pointed attention of our audience, and to point out the directions in which they can be partially abated, if not fully remedied. If, therefore, we at all venture to offer these remarks, it is simply in the hope that even a stringing together of such facts as have struck us rather forcibly as lying at the root of the evils which have led to the causation and spread of various diseases in this city may have its value in helping to concentrate the attention of our hearers to the subject of the mal-hygienic conditions of our city as a whole. We are quite as well aware, as many of our hearers here are, that some of the measures discussed have already been carried out, some again are taken in hand, while some others are being yet considered by the Municipal Corporation, the City Improvement Trust, and the Government. But their progress has been, comparatively speaking, slow and even halting at times, and perhaps necessarily so. In view, however, of the urgency and importance of some of these measures, as influencing very materially for the better the present heavy mortality in the city's population, it is very necessary that those already taken in hand should be rapidly pushed forward to an early completion, while those that are still "under consideration" should be taken up without any more delay.

APPENDIX B, TABLE No. 2.

Year.	Population of the City of Bombay.	Total Deaths. Including Plague.	Total Deaths. Excluding Plague.	Average rates per mille for quinquennial periods. Including Plague.		Average rates per mille for quinquennial periods. Excluding Plague.		Names of Health Officers of the quinquennial periods.	Average expenditure on the Health Department for each quinquennial period (in Silver).		Average Municipal Income during the quinquennial periods (in Silver).		Rates of expenditure on Health Department to the average income.
									Rs.		Rs.		
1872	644,405 Census, 1872.	18,990		29·46	26·71			Dr. Hewlett.	7,41,482	Rs.7,54,060	30,48,331	Rs.31,24,321	1 to 4·14
1873		15,665		24·30					7,93,661		33,24,107		
1874		15,496		24·04				" T S. Weir.	7,88,139		29,81,322		
1875		18,734		29·07					7,42,958		31,43,526		
1876		20,783		32·25	40·38			" T. S. Weir.	7,07,680	Rs.7,61,566	31,77,723	Rs.32,31,474	1 to 4·23
1877		33,511		52·00					7,49,560		32,41,452		
1878		26,999		49·90					7,90,480		31,45,153		
1879		22,527		34·96					8,04,294		33,41,174		
1880		21,146		32·81					7,55,829		32,51,870		
1881	773,196 Census, 1881.	21,856		28·27	28·51			Dr. Weir, Mr. J. Leask and Surgeon D. O. Davidson.	7,73,878	Rs. 9,66,489	38,73,964	Rs. 41,82,263	1 to 4·32
1882		20,468		26·47					10,16,345		46,12,240		
1883		23,530		30·43					9,19,592		37,37,272		
1884		22,544		29·15					9,23,311		42,13,868		
1885		21,850		28·26					9,99,322		44,73,973		
1886		20,074		25·96	27·65			Dr. Weir and Surgeon-Major K. R. Kirtikar	10,13,693	Rs.11,47,107	49,01,814	Rs.53,08,521	1 to 4·62
1887		20,513		26·53					10,75,735		51,66,530		
1888		22,421		29·00					11,56,409		49,66,193		
1889		23,378		30·24					11,96,610		53,42,169		
1890		20,534		26·56					12,93,092		61,65,901		
1891	821,764 Census, 1891.	23,847		29·01	30·64			Do.	12,83,354	Rs. 13,33,985	62,33,183	Rs. 65,93,980	1 to 4·94
1892		26,518		32·26					13,01,562		66,72,943		
1893		23,142		28·16					13,39,613		67,62,695		
1894		27,330		33·25					13,70,167		65,39,372		
1895		25,081		30·52					13,75,233		67,61,710		
1896		33,451	31,515	40·81	65·51	38·35	50·83	Dr. Weir, Mr. J. Leask and Dr. Turner.	14,09,867	Rs.17,75,959	62,08,978	Rs.75,49,822	1 to 4·25
1897		47,896	36,893	58·28		44·89			15,86,632		71,45,560		
1898		51,961	33,776	63·23		41·11			16,89,174		71,61,911		
1899		56,434	40,638	68·67		49·45			20,30,443		88,29,817		
1900		79,350	66,065	96·56		80·39			21,63,683		84,02,348		
1901	776,006 Census, 1901.	59,495	40,759	77·66	56·32	52·52	41·21	Drs. Turner and Cayley.	19,87,053	Rs. 19,60,256	77,66,729	Rs. 85,70,738	1 to 4·37
1902		48,414	34,594	62·38		44·57			20,06,990		81,75,688		
1903		50,513	29,725	65·[illegible]9		38·30			19,79,373		84,82,625		
1904		42,676	29,138	54·99		37·52			18,46,401		93,36,111		
1905		47,712	33,514	61·48		43·18			19,81,365		90,92,539		
1906	977,822 Census, 1906.	52,874	42,051	56·07		43·00		Dr. Turner and Dr. Venis.	21,10,094		96,48,501		1 to 4·57
1907		38,627	32,227	39·50		32·95			22,50,855		98,89,324		1 to 4·39

Appendix C, Table No. 3.

Census Year.	Total Population.	Total No. of Deaths in each Census Year.	Death-rate per 1,000.	
1872	644,405	18,990	29·46	
1881	773,196	21,856	28·26	
1891	821,764	23,847	29·26	
			For 1905 Including Plague.	For 1905 Excluding Plague.
1901	776,006	59,495	76·66	52·52
1905-06	975,000	47,762	48·98	34·42

Appendix D, Table No. 4.

Parsi Mortality.

Year.	Population.	Total Deaths.	Annual Death-rate per mille.	Decennial Death-rate.
1872	44,091 Census, 1872	1,254	28·44	
1873		969	21·97	
1874		984	22·31	
1875		1,062	24·08	
1876		1,047	23·74	
1877		1,016	23·04	
1878		1,102	24·29	
1879		902	20·45	
1880		888	20·14	
1881	48,597 Census, 1881	977	20·10	Between 872-81=23·36 per mille.
1882		896	18·43	
1883		1,116	22·96	
1884		1,111	22·86	
1885		993	20·45	
1886		1,041	21·42	
1887		995	20·47	
1888		1,102	22·67	
1889		1,112	22·88	
1890		1,026	21·11	
1891	47,458 Census, 1891	1,105	23·28	Between 1882-91=21·60 per mille.
1892		1,129	23·78	
1893		1,057	22·27	
1894		1,035	21·86	
1895		1,089	22·94	
1896		1,334	28·10	
1897		1,548	32·61	
1898		1,857	39·13	
1899		1,656	34·89	
1900		1,786	37·63	
1901	46,231 Census, 1901	1,412	30·54	Between 1892-1901= 29·26 per mille.
1902		1,405	30·41	Last quinquennial 1902-06
1903		1,367	29·56	
1904		1,281	25·54	
1905		1,381	28·50	
1906	48,824 Census, 1906	1,491	30·53	Between 1902-06=27·95 per mille.
1907		1,309	26·89	

Appendix E.

According to the census of 1901 in a total area of about 14,343 acres there were 38,843 dwelling places for the accommodation of 776,000 people, giving an average of about 20 persons to each dwelling. The latest census returns, *viz.*, those of 1906, give an area of 14,386 acres with 43,800 buildings, for a population of 977,822, giving an average of 22·32. Even in the year 1872, that is fully 36 years ago, the overcrowding in the city was considered by the then Health Officer, Dr. Hewlett, as excessive. But it has not only kept pace with the growth of the city since then, but has actually exceeded that of any other period in its history during the last five years. Notwithstanding that a fairly large number of dwellings have been demolished in various parts of the city by the operations of the City Improvement Trust, as already stated, during the last 10 years, and that building operations have not quite kept pace with this demolition, the last census (1906) shews that the population has increased to close on a million. This gives an increase of nearly 334,000 people over the census of 1872, and about 200,000 over that of 1901. The total density of population for the whole Town and Island of Bombay has, within a period of only five years, increased from 51·47 in 1901 to 67·97, in 1906. Unfortunately, however, *this overcrowding* is not spread out more or less evenly in all parts of the city. *It is concentrated a great deal more in some of its most unhealthy and low-lying parts.* For example the density of the population per acre in the Bhuleshwar District was 503, in Umarkhadi 508·9, in Kamathipura 551·6, in Chuckla 569·2, in Khara Talao 646·8, in 2nd Nagpada 647·5 and in Kumbharwada 711·71; as a natural consequence these districts are the most unhealthy, and stand considerably higher over the rest of the city as regards the incidence of various diseases and their death-rates. But the real nature of this overcrowding becomes even more apparent when we consider that in the year 1901, *80·86 per cent. of the city's population lived in only one room tenements* (against 6·7 per cent. of the city of London); nearly 25 per cent. lived at the rate of 6 to 9 persons to each room, about 11·74 per cent. at the rate of 10 to 19, and about 2·88 per cent. or about 21,000 people, in rooms each containing over 20 persons. (*Vide* Sir Bhalchandra Krishna's pamphlet on overcrowding.) Most of these rooms are not more than 10 by 12 ft. and they serve all the purposes of a sitting, dining and sleeping room, as well as a kitchen, combined in one. The overcrowding and insanitary condition of such rooms can thus be well imagined. In some of these poor residential quarters the overcrowding is simply appalling.

DISCUSSION.

Dr. Sorab Nariman, M.D., D.P.H., in the course of discussion on the paper, emphasized the evils of over-crowding and pointed out that in Murzban's chawls, which were near the flats and some of the worst stables, the percentage of mortality was much less than in any other chawls in Bombay, simply because there was ample space provided in them. They must adopt vigorous measures to lessen over-crowding. He regretted to say that in the Fort three or four storeyed houses of some

60 or 70 feet high were allowed to be put up and additional stories were put on in the case of old houses even. Mr. Murzban's chawls were only one-storied ones, with ample space in front and rear, and the immunity from plague and the low general mortality in the chawls could be traced to the fact that they were less over-crowded. Dr. Nariman then referred to a statement made in the paper on "Unhygienic Bombay" that London spent on its Health Department only about $\frac{1}{50}$th of the Municipal income, whereas Bombay Municipality spent as much as $\frac{1}{8}$th or $\frac{1}{4}$ of its income, and said that apparently there was some error, as such could not be the case.

Dr. Jehangir J. Cursetji replied that the mortality in Marzban's chawls was no doubt less owing to fewer people living in the chawls, and also on account of large free space left between the different blocks of buildings. He admitted that the greatest and the most important defect in the sanitation of Bombay was the dense over-crowding in the city. As regards the London expenditure on its Health Department he said that he learnt after the paper was printed that in the information supplied to him expenditure on conservancy, &c., was not included and hence the percentage given in the paper was not correct.

INDIA, THE HAJ AND THE INTERNATIONAL SANITARY CONVENTIONS.

By F. G. CLEMOW, M.D., D.P.H.

British Delegate on the International Board of Health at Constantinople, British Delegate on the Mixed Commission for Revision of the Ottoman Sanitary Tariff, etc.

The relation of India and the Indian Government to the International Sanitary Conferences and to the Conventions that have followed them is of an exceptional character. For the large majority of nations represented in those gatherings, the most important objects of discussion have been the measures intended to protect their respective territories from the *importation* of plague, cholera or yellow fever from elsewhere. Measures to prevent the *exportation* of those diseases from their shores to other countries did not come up for consideration and are scarcely mentioned in the Conventions.

But, in the case of India it is just the contrary that holds good. There plague and cholera are more or less permanently endemic and widely diffused, and India is exposed to no danger from yellow fever. Consequently, the measures to prevent fresh importations of those diseases are of relatively little importance or interest to her. But the question of measures to prevent the exportation of the two first-named diseases assumes, in consequence of the facts just pointed out, a primary importance, and involves the Indian Government in no little responsibility in the eyes of the rest of the world. This responsibility, great at all times, becomes accentuated when each revolving year brings round the season of Moslem Pilgrimage. The reason is obvious; many thousands of pilgrims of all classes then leave India for the Holy Cities of Islam; they have been the principal means in the past of carrying cholera to Arabia, which has then become the starting-point of an European or world-wide epidemic; and in the last twelve years anxiety has naturally been felt lest the infection of plague should be spread in like manner.

The object of the present paper will be to consider, as briefly as possible, the measures that have been devised by India herself and by the powers at successive Conferences to deal with these dangers.

One of the earliest measures taken by the Indian Government to control the spread of cholera from Indian ports was, I believe, the passing of the Native Passenger Act of 1858. This has been followed at intervals by other Acts of a similar character, of which the most important have been the Native Passenger Ships Act of 1876, the Native Passenger Ships Act of 1887, and the Pilgrim Ships Act of 1895. Other Acts, such as the Bombay Act of 1887 and the Bengal Act of 1896, have been passed for the protection of Muhammadan pilgrims; but, from the point of view of international disease-prevention, the Pilgrim Ships Act of 1895 (together with the Rules issued under it) is by far the most important. It repealed, in whole or in part, some of the preceding Acts, and is the main Act in force at this day.

The real importance and utility of these successive Acts can scarcely be over-rated. They have, from the first to the last, formed the basis upon which successive International Conferences have drawn up the sanitary measures to be applied for the control of the spread of disease by the Pilgrimage and even by other means; and those Conferences have more than once given expression to the debt of gratitude they owed to the Indian authorities, as the real pioneers in these matters.

It will be of interest to discuss briefly the attitude of those Conferences, and the action taken by them, in connection with this particular branch of international prophylaxis—the prevention, that is, of the spread of disease from India, more particularly by means of Moslem pilgrims.

The *International Conference of Paris*, 1851, did not, I believe, touch on this point.

The *Constantinople Conference of* 1866—the real starting-point of modern international measures—most cordially approved of the Indian Native Passenger Act of 1858. It thought that it would not be wholly impossible to stamp out cholera in India, and that in any case the disease could be controlled by proper hygienic measures—some of which, it freely admitted, had already

been carried out by the Indian Government. With regard to the pilgrimage danger, it urged:—

(1) That the number of pilgrims should be limited as much as possible, by obliging them to obtain written authority to leave India, such authority to be given only if they could show that they had enough funds for the whole pilgrimage ;

(2) That hygienic measures should be applied in the places the pilgrims passed through, and

(3) That groups of pilgrims in which cholera had actually appeared should not be allowed to depart until the epidemic among them had entirely ceased and they had undergone a general disinfection.

In view of later developments, it is of particular interest to note that this Conference also decided " that restrictive measures, known beforehand and properly applied, are much less prejudicial to commerce and international relations than the disturbance to trade and commercial transactions resulting from an invasion of cholera," and that " the nearer to the original foyer of cholera the measures of quarantine, etc., are applied the less onerous those measures are and the more efficacious do they become (if properly carried out) for the protection of Europe."

In these decisions taken over forty years ago may be found the germs of all the subsequent proposals and decisions in connection with the subject under discussion.

The *Vienna Conference of* 1874 confirmed the above decisions, without adding to them. This Conference also paid a tribute to the efforts of the Indian Government to control the spread of cholera.*

The *Washington Conference of* 1881 dealt only with yellow fever.

The *Rome Conference of* 1885 made no new proposals as to measures to be taken in India before the departure of pilgrims.

The *Venice Conference of* 1892 was the first one to be followed by an International Sanitary Convention. This Convention dealt mainly with the questions of the passage of the Suez Canal in quarantine and the reorganisation of the Alexandria Quarantine Board. It did not directly touch the question of India.

The *Dresden Conference of* 1893 also did not deal with the question under discussion.

The *Paris Conference of* 1894, on the other hand, was mainly concerned with the pilgrimage to the Hedjaz. It laid down clearly, for the first time, the measures to be taken before the departure of pilgrims " from ports of the Indian Ocean and Oceania." These may be briefly summarised as follows :—

(1) Medical inspection of pilgrims, by day, on shore, before departure.

(2) Disinfection of contaminated or suspected objects.

(3) Cases, true or suspected, of cholera to be prevented from embarking.

(4) Five days' observation before departure, if cholera were present in the port of embarkation—" so far as local possibilities and circumstances permitted." In the case of ships from India, the five days were to be allowed to count on the voyage between India and Aden.

(5) Pilgrims were to prove the possession of means for the journey out and back. This point was not, however, accepted by the British Government.

The *Venice Conference of* 1897 dealt with plague only and was, indeed, the consequence of the appearance of plague in India in 1896. The Convention which followed it required, for both passenger ships and pilgrim ships leaving contaminated ports " outside Europe," (1) a medical inspection, by day, on shore, of all persons embarking, (2) disinfection of contaminated or suspected objects, and (3) plague-infected persons to be prevented from embarking. For pilgrim ships it further required (1) five days' observation before departure, " if local circumstances and possibilities permit," and (2) pilgrims to prove the possession of means for the journey out and home, also " if local circumstances permit."

The *Paris Conference of* 1903, the most recent of the Conferences, codified the decisions taken by itself and by the preceding ones. The Convention which followed requires in the case of pilgrim ships leaving a port in the Indian Ocean or Oceania—even if the port be not infected with plague or cholera—a medical inspection, by day, on shore, of all persons embarking on the ship, measures to prevent the embarkation of infected persons or of infected goods that have not been previously disinfected, and (in the case of plague) measures to prevent rats gaining access to the ship. In the case of an infected port it further requires that the pilgrims shall have undergone a quarantine " to insure that none of them are suffering from plague or cholera,"—so far as local circumstances permit; and it also requires the pilgrims to prove the possession of funds for the whole journey.

It is obvious that the above is only a very brief summary of the clauses of the different Conventions dealing with the one particular point—the measures to be applied in India before the departure of the pilgrims. The Conventions contain also a large number of other clauses laying down the conditions which are to be fulfilled by pilgrim ships as regards their sanitary state, their navigability and so forth, and to these I shall recur later.

It will be seen that the chief measures required before the departure of the pilgrims have been : (1) medical

* It is interesting to note, in this connection, that the Vienna Conference proposed the creation of a permanent " International Commission on Epidemics," the cost to be borne by the different Powers, who would be asked to contribute in proportion to their respective populations ; but it was added that " It would be unjust that England, who makes such great efforts for the extinction of cholera in India, should be asked to contribute in proportion to the populations of her possessions to expenses, the final object of which is to prevent the extension of epidemic disease. "

inspection with its corollary—the prevention of the departure of actually infected pilgrims, (2) disinfection of their effects, (3) a period of isolation before departure —or, in other words, a preliminary quarantine, and (4) the prevention of access to the ship of plague-infected rats. Let us see now what measures have actually been applied in practice by the Indian authorities. They are shown, for the last twelve years, in the following table:—

Year.	Ports of departure.	No. of pilgrims who left India.	No. of Indian pilgrims who arrived at Camaran.	Measures applied in ports of departure or elsewhere in India.
1896-97..	Calcutta & Madras. (after Feb. 1st, 1897).	?	2,493	After Feb. 16. 1897, Pilgrimage from Bombay Presidency and Sind prohibited. After Feb. 20th Pilgrimage from India wholly suspended.
1897-98..	Chittagong	915	880	Pilgrimage partly suspended. Medical observation (duration not stated) before departure. General advice to Muhammedans to defer their Haj to more favourable epoch. (This has been repeated each season since.)
1898-99..	Do. ...	1,446	1,333	Medical observation (duration not stated) before departure, and disinfection (apparently for the first time).
1899-1900.	Do. ...	1,630	1,608	The same.
1900-01..	Karachi & Chittagong	2,879	2,907	The same for pilgrims from uninfected places; departure of those from infected places prohibited.
1901-02 .	Porbandar and Chittagong	4,666	4,772	The same. (The "observation" in the Madras Presidency, was for ten days.)
1902-03..	Bombay, Karachi & Chittagong	5,125	5,374	The above restrictions partly removed. Observation before departure carried out near the pilgrims' homes (instead of in port of departure).
1903-04..	Bombay & Chittagong	16,952	15,955	The Haj opened to any resident in India. Central "observation" camps; duration of observation apparently ten days.
1904 05..	Bombay ...	12,449	11,402	The same; but observation reduced to five days.
1905-06..	Do. ...	18,390	15,210	The same.
1906-07..	Do. ...	?	23,202	Observation before departure done away with. Ships to have their rats destroyed by the Clayton method. Disinfection. Fresh inspection at Aden and Perim. Plague Camp put up at Perim.
1907-08..	Do. ...	?	17,954*	The same as in 1906-07.

It will be seen, from the above table, that in the last twelve years serious measures have been applied in India to departing pilgrims. They have varied from time to time. For the whole period the ports of departure have been limited to one, two or three. From 1896 to 1898 the Haj was partly suspended. For the whole period Muhammedans have been advised to postpone their Haj to a more favourable epoch. From 1897 to 1906 a period of observation varying from ten to five days was applied to the pilgrims either near their homes or in central observation camps at or near the port of departure. From 1898 to the present year disinfection has (apparently) been included in the measures. The departure of pilgrims from actually infected territory was prohibited or restricted until the year 1903-4, since when the Haj has been open to any resident in India, under the conditions specified in the table.

That the measures thus briefly summarised have been highly efficacious there is every reason to believe. After the pilgrims have undergone them, they are all (or practically all) carried by steamers directly to the lazaret of Camaran, near the south end of the Red Sea, where further measures are applied to them; and it is from the records of that lazaret that the proof is forthcoming of the efficacy of the Indian precautions in question. The following facts are indeed eloquent and scarcely require comment. Before the year 1890 the records of the lazaret are incomplete; but between 1890 and 1895 (*i.e.*, in six years) cholera was imported to Camaran from India on no less than 7 occasions (once in 1890, once in 1891, twice in 1893 and three times in 1895). The serious measures above detailed were put in force by the Indian authorities for the first time in 1896-7; and from that time until the winter of 1907-8 neither plague nor cholera was imported to the lazaret from India on a single occasion. The contrast is very striking; the measures were applied primarily in connection with the epidemic of plague, but they have proved to be equally efficacious in preventing the spread of cholera.

In the winter of 1907-8, however, cholera was, after a lapse of twelve years, again imported to Camaran from India; and that not once but twice in the same pilgrimage. (Three cases occurred on each of two steamers in November-December, 1907). Now it is a fact that in the preceding season the measure of observation of the pilgrims before departure from Bombay (*i.e.*, a preliminary quarantine) had been suppressed, and it is difficult not to attribute the sudden importation of infection, on two separate steamers, to Camaran to this cause.† Briefly—in six years (1890-1895) when no special precautions before departure were in force, cholera was imported to Camaran from India 7 times; in twelve years (1895-1907) when rigorous precautions were in force, it was not imported at all; but, when the preliminary observation was removed from the list of those precautions, this was soon followed by the importation of cholera to Camaran, on two different steamers, in the same pilgrimage. ‡

* The discrepancy between the figures in the 3rd and 4th columns of the table are explained, partly by the occurrence of deaths on the voyage between India and Camaran; partly by the facts that a few Indian pilgrims choose other routes, and that some come from Aden, Muscat and the Persian Gulf; and partly by the inclusion of Afghans and other races in the Indian figures, while the Camaran figures refer to Indians only.

† This view is unfortunately confirmed by the occurrence, since writing the above, of a fresh importation of cholera to Camaran, at the end of November 1908. See Postscript.

‡ It is of importance to note that the cholera epidemic in the pilgrimage of 1907 was not the consequence of these importations. The infection of that epidemic was brought from the norto, by pilgrims arriving at Yanbo, and was in all probability of Russian origin.

The suppression of the preliminary isolation of the pilgrims before departure was necessitated by local causes. The Moslem year being eleven days shorter than the solar year, the Haj or Pilgrimage falls each year eleven days earlier. Until 1906 the period of the departing Haj fell in the winter months; but since then it has begun to fall, partly at least, in the autumn, before the monsoon rains are over, and it has consequently been found impossible to arrange an isolation camp near Bombay as in previous years. For the next ten or twelve years the same conditions will obtain—the period of departure, slowly receding each year through the rainy season, until about 1920 or so, when it will fall in the spring, before the monsoon bursts. It would certainly be a great gain to international prophylaxis if this difficulty of arranging for the isolation of the pilgrims before departure could be overcome. No doubt during the rains they cannot be lodged in a mere camp; but the question arises whether it would not be possible to build a series of barracks or sheds, to protect them from the rains, and thus enable the preliminary observation to be carried out as in the recent past.

The real value of this observation has been shown by the history of cholera at the Camaran lazaret, as recounted above. It could, no doubt, be further illustrated by the record of cases of cholera or plague in the observation camps themselves. I regret that I am not in a position to furnish this record. I venture to express the hope that this missing information may be forthcoming in the course of the discussion that may follow the reading of this paper.

Frequent mention has been made above of the lazaret of Camaran. This very important institution is not perhaps as well known as it deserves to be. Early in 1906, I had occasion to visit it, as member of a Committee of Inspection sent by the Constantinople Board of Health. The Commission spent some 17 days in the lazaret itself.* This lazaret was brought into existence as the result of the International Sanitary Conference of Constantinople (1866). That Conference decided: (1) that a sanitary establishment should be created near the entrance of the Red Sea; (2) that the international character of this establishment was a *sine qua non*, the form to be given to the institution and to the measures to be applied there being left to the Governments interested, with the suggestion that the lazaret should be placed under the direction of either Turkey or Egypt, but under the control and with the assistance of Europe; and (3) that the measures applied there would be based on an international regulation and executed by an authority placed under the control of the Governments interested. Camaran was ultimately selected as the best site. The lazaret there first came into being in 1881. It was much enlarged and perfected, at considerable cost, in the years 1896-98. It is in many respects an admirable institution. It has certain serious defects, which are now being remedied; but in all essential matters, when the new works are carried out, it will be one of the best as well as one of the largest lazarets in the world.

This lazaret is under the control of the Constantinople Board of Health. It is opened during the six months of Pilgrimage; a large permanent staff remains there all the year round, and for the pilgrim season an "annual mission" is sent there, composed of from 7 to 10 doctors, and a large number of other officials and employés.

The measures applied at Camaran to the pilgrims are laid down in a set of regulations, the "Règlement Spècial applicable au Pèlerinage du Hedjaz," which is annually revised by the Constantinople Board of Health. Those measures, as applied to Indian pilgrims, have been the subject of complaint, as being unnecessarily stringent, particularly in the matter of the lengthy period of quarantine applied to them. Until the year 1905, that period was one of ten days for pilgrim ships from any Indian port. In 1905, as the result of representations made by myself, the Board of Health consented to reduce the period to one of five days, in view of the measures taken in India before the departure of the pilgrims. But the effective application of that reduction was postponed for a year, owing to the alleged deficiencies in the Camaran lazaret, and for certain financial and other reasons. That same year, at my suggestion, the Commission of Inspection above referred to was sent to inspect the lazaret and made an elaborate report on its return, containing detailed proposals for the improvement and completion of that institution. In the following year (1906), the Board reduced the quarantine to five days for pilgrims that had undergone measures in India, including five days' preliminary isolation before departure. Unfortunately just at that moment came the news that the Indian Government had abandoned this measure, and so for that season again the ten days' quarantine at Camaran was retained. But in 1907-08, and again in the present pilgrimage (1908-09) the quarantine has been reduced to seven days for pilgrims who have undergone medical inspection and disinfection before leaving India, and who are carried in ships that have been disinfected and had their rats destroyed.

The measures at Camaran, even as they now stand, are certainly much more stringent than those laid down in the International Convention of Paris (1903) (Arts. 126-128). That Convention requires, for "clean" ships from infected ports, only disinfection of the pilgrims' effects, and the giving of a douche bath to the pilgrims—the whole detention of the ship not to exceed 48 hours. For "suspected" ships (*i.e.*, those on which cases of cholera or plague have occurred, but no fresh case for seven days) the measures are practically the same; and even for "infected" ships the quarantine is only one of 5 days for cholera and 7 days for plague. It will naturally be asked why the Board of Health at Constantinople has insisted upon retaining measures so much

* The results of the Commission's labours were embodied in a series of printed reports, addressed to the Board of Health. They were also summarised in a series of articles contributed by the Author to *The Lancet*, and published in that journal during the summer of 1907.

more stringent than these. The reason is fourfold. Firstly, Turkey has not accepted the Paris Convention; secondly, the Board has been seriously impressed by the enormous mortality from plague and cholera in India in recent years; thirdly, doubt has been felt as to the adequacy of the Camaran lazaret and the efficacy of the measures other than quarantine applied there; and finally some influences must be ascribed to the pecuniary loss to the lazaret's income which would undoubtedly result from a reduction or abolition of quarantine there.

I can only touch very lightly here on these points. With regard to the first, Turkey has unfortunately not accepted the International Convention, or has signified her readiness to do so only under "reserves" that would have annulled a great part of their provisions. With the change of regimé, however, in this country, it is not impossible that she may be induced sooner or later to come into line with the other Powers in accepting, if not the whole, at least all the purely sanitary clauses of the Paris Convention.

With regard to the second point, it must be admitted that a certain amount of disquietude at the mortality in India was natural and indeed justified. The following figures show the numbers of deaths in India, from cholera and plague, respectively, in each of the last five years:—

Year.	Deaths from Plague.	Deaths from Cholera.
1903	865,717	314,311
1904	1,143,933	193,657
1905	1,069,140	441,786
1906	356,721	713,664
1907	1,200,735	408,102 (in British India only).

Thus, from a million to a million and-a-half deaths from these two diseases alone have been occurring annually in the last few years, and the last year of the series furnished the highest total of all. No one could be taxed with being alarmist for regarding these figures as of very real gravity. It will consequently be readily recognised that, under these conditions an endeavour to obtain a great reduction in the measures of quarantine applied at Camaran on pilgrims from India, was likely to meet with difficulties, that those difficulties were increased by the fact that India had herself just before struck off from her list of measures the five days' observation before departure, and that they were not diminished by the sudden importation to Camaran of cholera on two ships, after an interval of twelve years without any such importation occurring.*

With regard to the third point, the doubt as to the adequacy of the Camaran lazaret to apply other measures efficiently, that doubt has been largely dissipated, as the result of the labours of the Commission of Inspection before referred to. In respect of its water-supply, and of its truly admirable arrangements for disinfection and for giving of douche-baths to the pilgrims, the Camaran lazaret compares favourably with any other institution of the kind with which I am acquainted. One of its most serious defects—the latrine arrangements—has already been partially remedied, and will shortly be wholly so; on the proposal of the Commission, a system of trough closet with automatic flushes and proper drains (of the best material, supplied by the firm of Jennings & Co., of Lambeth) has been tried in one of the cordons of the lazaret; it has so far given good results, and the system will shortly be extended to the rest of the lazaret. A large number of other improvements will also shortly be put in hand, a sum of £T. 33,000 (£30,000 sterling) having recently been voted for the purpose.

With regard to the fourth point—the financial side of the question—it is obvious that the duration of a quarantine should on no account be determined by considerations of this nature. To impose, or prolong, a quarantine, as a source of income is obviously inadmissible. But it has equally to be remembered that the taxes collected are in proportion to the length of the quarantine, and that the income of a lazaret does diminish if the quarantines are shortened. These large institutions are costly establishments, and have to be kept up by some means. To this I shall refer again later, and will only add here that the whole question of the taxes levied in Turkish ports is now being dealt with by the proper body—the Mixed Commission for the Revision of the Ottoman Sanitary Tariff, now sitting in Constantinople.

I have referred in an earlier part of this paper to the clauses of the Paris Convention laying down the conditions to be fulfilled by pilgrim ships as regards their sanitary state. It is satisfactory to be able to state that pilgrim ships from Indian ports are among the best of those arriving at Camaran in regard to their cleanliness, absence of overcrowding and compliance with every other sanitary requirement. The reason is that they are compelled to conform with the Rules framed by the Government of India under the various Pilgrim Ships Acts already mentioned. Those Rules are not only excellent in themselves, but they are very strictly applied by the Indian authorities to the ships leaving their ports. The contrast between such ships and others (even under the British flag) from ports of the Persian Gulf or elsewhere, where there is no means of enforcing compliance with the Rules, is very striking. I can affirm this, not only on the authority of the annual reports for many years past of the Camaran and Jeddah medical officers, but also from what I myself saw when staying in those ports in 1906.

There is, however, one point in which the equipment of pilgrim ships from India is apt to fall short. In several instances complaints have been made of the inefficiency of the medical officer which such ships are compelled to carry. Sometimes the complaint has been that he has made incorrect declarations as to the state of health of the pilgrims on board on their arrival at Cama-

* These difficulties will again be increased by the fresh importation of cholera in Camaran in the present Haj. See postscript.

ran or Jeddah. In some such instances he has officially declared that there was no sickness on board whereas, on landing the pilgrims, several have been found seriously ill, and even dying; thus showing that he had either wilfully made an untrue statement, or was culpably ignorant of the health of the pilgrims under his charge. Very frequently the ships' papers show that deaths that have occurred during the voyage have been vaguely certified as due to "general debility," or "fever," or some such indefinite term, indicating that imperfect attention to an exact diagnosis has been paid. There seems, in fact, to be little doubt that there is marked room for improvement in the class of medical officers carried by many of the pilgrim ships that leave Indian ports.

Another frequent source of complaint in the past has been the large number of indigent pilgrims from India. They have proved a cause of trouble, firstly, in refusing to pay their quarantine dues at Camaran, and even in requiring to be fed in addition at the expense of the lazaret authorities; and secondly, from the fact that many of them, after the fêtes at Mecca are over, have no money for their return journey, and remain, in a penniless state, in the streets of Jeddah—a danger to the health of the town, and a source of anxiety and difficulty to the local authorities and to the British Consul there. This matter has been frequently discussed in successive International Conferences, and the later Conventions have each contained a clause requiring—"if local circumstances permit"—pilgrims to prove the possession of means for the whole pilgrimage, and particularly of a return ticket. The Indian Government in particular has been urged to take steps to make these conditions compulsory, but hitherto has apparently found it impossible to do so. In the last few years, however, the Indian Government has "advised" pilgrims "to have sufficient money with them to enable them to meet the cost of the journey, and to provide themselves with gold to pay the sanitary dues at Camaran." I shall refer again to this last point; but, in regard to the main consideration, it would be very desirable that the Indian pilgrims should be not merely advised, but compelled to prove the possession of adequate funds and to have return tickets. Pilgrims from the Dutch East Indies, from Egypt and from Morocco, are compelled by their respective Governments to give such proof, and have even in some years been obliged to deposit a large sum of money with the local authorities before their departure. No doubt the average Indian pilgrim is exceedingly poor; but the Moslem religion actually requires that its followers should only go on pilgrimage if they have the necessary funds, and if they have provided for their families during their absence. There would surely seem to be no reasonable objection to a Government insisting on its pilgrims complying with one of their own religious laws.

In some instances there can be no doubt that pilgrims have pleaded poverty and so escaped paying their quarantine dues at Camaran, when they had in truth ample means to pay them. It would be easy to mention a number of tricks to which they have resorted in the past to avoid paying those dues.* The abuse was for some years a very serious one, and the loss to the lazaret was great. This is shown by the following figures:—

Year.	Percentage of Indian pilgrims who paid their dues at Camaran.	Percentage of Indian pilgrims who did not pay their dues at Camaran.
1903-4	67·64	32·36
1904-5	58·74	41·26
1905-6	69·02	30·98
1906-7	66·42	33·58
1907-8	100·	0·

The sudden fall to zero in the number of "non-paying" pilgrims in the last year of the series was the result of a decision taken by the Constantinople Board of Health in 1907, requiring the quarantine dues at Camaran to be paid "*en bloc*" by the ships' captains, who now include the sum in the price of the tickets. This measure is strictly in accordance with Article 93 of the Paris Convention of 1903. It is applied equally rigorously at the Egyptian lazaret of El Tor, and is, in fact, a very practical and useful measure. For as I have already remarked these large lazarets are costly institutions, and they must be provided by some means with an adequate income to keep them up. This brings me to a very important point—the attitude of India towards the very existence of the lazaret of Camaran. As I have shown above, this lazaret was brought into being under an International agreement; it has been built with funds derived from International sources, and the application of measures to pilgrims there is compulsory under the International Conventions—which have been accepted and ratified by His Majesty's Government and by those of the majority of other Powers. There can be no question of doing away with it, and letting the pilgrims go straight to the Hedjaz without any precautionary measures on the way. But, in order to keep it going, funds are absolutely necessary, and these are provided by the taxes levied on the pilgrims undergoing quarantine there. The amount of those taxes has been fixed, also under International agreement, by the body already mentioned—the Mixed Commission for the Revision of the Ottoman Sanitary Tariff. [This body has met four times since 1869 (the date of its first meeting), and is now sitting, for a fifth time, in Constantinople.] His Majesty's Government has consented to the levying of the taxes in question. Consequently there can, I think, be no legitimate objection to the step taken by the Board of Health at Constantinople, in making the payment of the taxes by the ship's captain or agent compulsory. The financial result of the measure has been excellent; for the Camaran lazaret,

* A favourite one is for a group of pilgrims to hand over all their money for the time to one of their number; he pays his dues; but the others refuse, pleading "indigency"; and in truth no money can *at that moment* be found on them. Many other tricks of the kind are, or were, resorted to.

which had for many years furnished a serious deficit, last year yielded a sufficient margin of surplus.

On the other hand, more legitimate objection may be, and is, raised by the Indian Government to the total amount of the taxes levied. That amount is, as I said before, proportioned to the length of the quarantine; and the Indian Government, in justly objecting to the quarantining of their pilgrims for far longer periods than the Paris Convention requires, object at the same time to the resulting additional cost to those pilgrims. I have already described the difficulties that lie at present in the way of diminishing the length of that quarantine, and the continued efforts that are being made to overcome those difficulties.

There remains one other point to be mentioned—the rate of exchange at which foreign coins are taken at Camaran. Formerly, the Indian rupee was taken there at the rate of only five and-a-half piastres (P. 5½), instead of the eight piastres (P. 8) which is its real value. When at Camaran and Jeddah in 1906, I found that even by the local money-changers the rupee was taken at the rate of 7¼ to 7¾ piastres. On returning to Constantinople, I succeeded in getting the rate at which the rupee is accepted, both at Camaran and Jeddah, raised from P. 5½ to a sum 20 paras (one penny) less than the local rate of exchange of the day. This works out at from six and three-quarters to seven and-a-quarter piastres. The result has been a very appreciable gain for the pilgrims who pay their taxes in rupees. The exchange rate of the English sovereign has also been the subject of complaint, as many of the captains now pay the dues in this coin. The sovereign is taken by the lazaret authorities at the rate of 109 piastres; whereas its full value is 120, and it is taken by the local money-changers in the Red Sea at 118 or 119. But in this instance (which was not the case with the rupee, whose value had been arbitrarily fixed at P. 5½), the rate of exchange has been regulated by an International agreement. The Mixed Commission above alluded to, in fixing the sanitary and quarantine dues, had laid down (Art. 8 of the Sanitary Tariff) that they were to be collected in Turkish money—"the Turkish pound at 100 piastres, the Medjidieh at 20 piastres." The Turkish pound is really equivalent to 108 piastres, yet it is taken by the sanitary authorities at only 100 (*i.e.*, 100 "gold" piastres). Consequently, all foreign gold coins have to be taken at their equivalent in "gold" piastres; and the equivalent of the English sovereign is 109 gold piastres. So long as the Tariff, which has been in force since 1871, remains unaltered, it will be impossible to take the English sovereign at any other rate.

Before closing this paper, I wish to say, that its main object has been to set forth briefly some of the facts in connection with a most important branch of International disease control. Many of those facts are perhaps little known to the profession as a whole; but I am convinced that the more they are known the better it will be for all concerned. The sanitary control of the Moslem Pilgrimage involves many and highly complex problems. The measures, devised to ensure that control, have been laid down in the International Sanitary Conventions; the execution of those measures, so far as regards the pilgrimage from India (the only points dealt with in this paper) lies firstly with the Indian Government, and secondly, with the Constantinople Board of Health. I have tried to show how each of these authorities discharges the onerous duties laid upon it, and to indicate some of the points wherein there is room for improvement on both sides. To that extent, I hope, the paper may prove not only of interest, but also of practical use. A fuller knowledge of what each of these authorities is doing, of the difficulties each has to contend with, and of the efforts made to overcome those difficulties, can only increase mutual respect and mutual confidence; and that will assuredly facilitate the execution of the responsible task that both are called on by the European Powers jointly to perform—the prevention, that is, of the spread of plague or cholera from India by the Moslem Haj.

POSTSCRIPT.

Since writing the preceding paper, and at the moment of posting it, news has been received of a fresh importation of cholera to Camaran by a pilgrim-ship from India. The ship, with 856 pilgrims on board, arrived at Camaran from Bombay on November 24th, 1908. On the night of the 28-29th, a member of the crew was landed with symptoms of cholera; on the 29th, two other members of the crew were also landed with the same symptoms. The results of a preliminary bacteriological inquiry have shown that the cases are almost certainly cases of cholera. This incident only serves to confirm the interpretation advanced above of the similar incidents in last year's pilgrimage, and to strengthen the appeal made to the Indian Government to consider the possibility of reviving the measure of five days' observation of the pilgrims before they leave the Indian shores.

DISCUSSION.

Lt.-Col. Crimmin, V.C., in criticism on the foregoing paper, said that Dr. Clemow appeared to be anxious that quarantine should be imposed on Indian pilgrims before they left India for Mecca. He was not satisfied that the author had made out a sufficiently strong case for the enforcement of quarantine in India. In any case there could not be much object in insisting on quarantine in this country as long as it was again enforced at Camaran irrespective of the prevalence or otherwise of infectious disease at the port of departure. The procedure with regard to Indian pilgrims was as follows:—The pilgrimship was freed from rats, all pilgrims, irrespective of class, were medically examined prior to embarkation and their clothing, bedding and other articles were disinfected on shore; the pilgrims were then under the observation of the medical officer of the pilgrimship for about nine days, *i.e.* during the voyage between Bombay and Perim at which latter port the ship was compelled to call. At Perim there was a pilgrim camp in charge of medical officers who examined the pilgrims on arrival, and if plague had broken out during the voyage, the pilgrims were placed in quarantine. The pilgrims next arrived at Camaran where the Turkish Government took them in hand and placed them in quarantine before they were allowed to proceed to Mecca or Medina. Regarding the remarks of the inefficiency of some of the medical officers on pilgrimships he would state, that efforts were being made to license only well-qualified

medical officers such as those holding the L. M. & S. from a recognised University. The pilgrim traffic was a most unpleasant one and there was some difficulty in getting suitable doctors to make more than a few trips on a pilgrim ship, the result was that there were doctors acting as medical officers of pilgrim ships who though fully qualified had little practical experience of the requirements of the Camaran sanitary authorities. If the Camaran authorities who were provided with stringent regulations found a doctor neglected or failed in his duty the remedy was obvious. Captains of pilgrim ships were now compelled by the Camaran authorities to pay the quarantine dues for all the pilgrims who went on their ships, so that there could not be any complaint about the Indian pilgrims being not able to pay their dues on account of poverty. It was true that many comparatively poor pilgrims made the Haj and it was the belief of some that the extra period of quarantine and the extra quarantine taxes referred to in Dr. Clemow's paper were imposed on them as a deterrent. Apparently poor pilgrims were not required anywhere. It was to be hoped that the extra quarantine and the extra taxes imposed at Camaran would be done away with in the immediate future as they pressed somewhat heavily on the pilgrims and on the shipowner. With reference to the report of two outbreaks in Camaran during the pilgrim season of 1907-1908 he was unable to say anything as he was absent from Bombay at the time. One thing was certain, that was that the attacks did not develop into an epidemic. As regarded the outbreak in the season 1908-1909 referred to by the author, the following points were worthy of note :—(*a*) the ship left Bombay on 13th November and arrived at Camaran on the 19th day ; (*b*) there was no cholera in Bombay at or about the time of the vessel's departure from that port, nor were any suspicious cases on board during the voyage ; (*c*) four members of the crew became ill about four days after the ship's arrival at Camaran, *i.e.*, about sixteen days after her departure from Bombay ; (*d*) only one of the four who were ill died: it was a very low rate of mortality for the commencement of an outbreak of cholera ; (*e*) from the statement in the paper under discussion it would appear that the bacteriological examination which was made at Camaran was somewhat doubtful ; and (*f*) none of the pilgrims on board who drank the same water as the crew were attacked. The doctor of the ship was of opinion that the attacks from which the four members of the crew suffered were brought on by the inordinate consumption of the fish which was abundant in Camaran. The occurrence of a marked increase in the number of cases of diarrhœa both among the crew and pilgrims of a ship after the vessel had been some days at Camaran, had frequently been recorded in the diaries of doctors in charge of pilgrim ships and he believed that this increase as well as some if not all of the so-called outbreaks of cholera must be due to some condition prevailing at Camaran. Dr. Clemow's paper was on the whole a flattering testimony to the manner in which the Government of India carried out their pilgrim obligations to Europe.

Dr. Blackmore stated that he was in agreement with the President in stating that Dr. Clemow had not made out his case for the reimposition of quarantine on pilgrims. Dr. Clemow based his suggestions on the fact that during the time of quarantine in Bombay not a single case of cholera was detected at Camaran, but it was a fact that no case of cholera had occurred in the quarantine camp at Bombay, so that the quarantine regulations were not responsible for the results mentioned by Dr. Clemow. During quarantine times the pilgrims were subjected to practically thirty days' quarantine—ten days at Bombay, ten days on the voyage and ten days at Camaran. Notwithstanding the stringency of the quarantine regulations in Bombay, the Turkish authorities refused to do away with their quarantine regulations, so that the pilgrims were subject to rules obtaining with no other passengers leaving India. The Mahomedan inhabitants of this country had a distinct grievance and a just cause for complaint so long as those conditions were allowed to prevail. Dr. Blackmore thought that the Turkish authorities might well be asked to take some steps within their own borders to prevent the provision of a special breeding place for cholera and other like diseases. The insanitary condition of Mecca, Jeddah, &c., was notorious.

Dr. Blackmore admitted that some of the medical officers on ships were not very efficient but urged that they did their work under very special difficulties and urged the appointment of a lady doctor also. He contrasted the treatment meted out to pilgrims by the Indian Government and the treatment received at the hands of the Turkish Government and their co-religionists.

The speaker paid a high tribute to the admirable manner in which the pilgrim regulations were carried out in Bombay under the energetic supervision of Lt.-Col. Crimmin, the President of their Section, which was a pattern to the whole world.

A NOTE ON
SMALL-POX ON BOARD OF PILGRIM SHIPS.

By Lt.-Col. J. CRIMMIN, v.c., c.i.e., m.d., d.p.h.

Small-pox is endemic and it frequently prevails as a virulent epidemic in the Holy Cities and other places in Arabia. Almost every year the Indian pilgrims who return from the Mecca Haj bring small-pox with them. During the past 12 months 27,209 Mahomedan pilgrims returned on 36 ships from Jeddah *via* Bombay to all parts of India. The average duration of the voyage is about 12 days and the pilgrims developed during the voyage 205 cases of small-pox. The number of pilgrims given above includes the whole of last season's and part of this season's pilgrims. The number of small-pox cases which occurred during the 12 months is above the average. All we can do at present in Bombay to protect India is to send the small-pox cases to hospital, disinfect by means of steam in suitable disinfecting chambers the clothing, bedding and other belongings of the ship-load of Hajis among whom small-pox occurred, and offer all the pilgrims vaccination free of charge. I am sorry to say that very few of the pilgrims accept the offer of vaccination.

Many of the returning pilgrims are incubating small-pox when they land in Bombay and they develop it later on in their villages up-country where they become foci of infection. And herein probably lies the greatest mischief. Placing the pilgrims in quarantine on their return from Mecca is not practicable nor would it be expedient. Compulsory vaccination of the returned Hajis would not be of very much use towards preventing the development of small-pox in those who are incubating it on arrival in India, nor would it prevent those who develop the disease from becoming foci of infection in their villages. If Indian pilgrims, who appear to be very susceptible to small-pox, were vaccinated, or revaccinated, as the case

may be, immediately before leaving India for Mecca many lives would be saved as well as much disfigurement and suffering. The deaths in British India from small-pox fluctuate considerably, but they may be taken as about 100,000 per annum.

DISCUSSION.

Dr. J. H. Turner, Health Officer of Bombay, said that as they were, no doubt, aware he had had considerable correspondence with Government and forwarded from time to time to the Corporation for several years suggestions for the control of importation of cholera and small-pox into Bombay. He believed that cholera and small-pox were as much introduced into India as taken out of it. In his capacity of Health Officer he had constantly to bring to the notice of the authorities the incidence of cholera through the medium of the Indian pilgrims returning from Jeddah to this country.

He had also had occasion to write and impress on the authorities that not only were epidemics due to pilgrims, but that they also were due to the importation of small-pox from the whole Southern Coast where vaccination was not practised.

Bombay was thus in constant danger from one or other source and both factors often operated simultaneously.

The two papers read were most valuable ones—one dealing with Europe, the other with India. And he wished to state that, in his opinion, Bombay was the most unprotected port in the world.

His audience knew what it was to offer vaccination to men like the pilgrims, and for that reason he hoped Government would accept the suggestion of the author as to vaccination and revaccination of pilgrims, but they had to remember that people came from Java and other remote countries where there was no vaccination and that not infrequently they brought small-pox to Bombay. In many instances pilgrims after arriving in Bombay died long before the ship was ready to take them away. And one of the reasons was that they had to live in conditions not favourable to them. He had no doubt that this would be remedied by the new Pilgrims Committee which had been established in Bombay, which he hoped would be able to provide better accommodation for the pilgrims in the near future.

Every precaution was taken to prevent cases of infectious diseases being taken on boardship and thus taken to foreign countries by the authorities in Bombay, but Bombay itself was unprotected against the importation of infections. This was an interesting and serious subject and he wished he had time to discuss it more fully.

Dr. Clayton enquired whether the medical officer on board had any lymph so that during the occurrence of cases he could vaccinate on the voyage out or home.

He imagined that sufficient fresh lymph for this purpose could be made available and it appeared to him that something might be done in that direction.

Lieut.-Colonel Crimmin explained that this was provided.

INCIDENCE OF TROPICAL DISEASES AMONG NAVAL MEN STATIONED IN WARM CLIMATES.

By F. H. A. CLAYTON, M.D., M.R.C.P. (Edin.),

Fleet Surgeon, R.N.

When I was honoured by the Central Committee with an invitation to read a paper before the Bombay Medical Congress it seemed desirable to select, as a subject, that suggested by the Committee, the Incidence of Tropical Ailments among Mariners, since the peculiar circumstances of Naval life add, even to negative evidence as regards their occurrence, a certain value in the elucidation of their etiology and thus render the subject perhaps more generally interesting than most others dealing with Naval hygiene.

Conditions under which the Sailor lives. The sailor may be described as to a large extent protected in most cases from the attacks of mosquitoes and other biting flies, to be usually provided now-a-days with an absolutely pure water-supply, and to have his food supervised and prepared under circumstances which militate against its contamination by any specific infection. Unlike most dwellers in the tropics, his arrangements for the disposal of excreta and refuse are of the simplest and most efficient description since everything is discharged directly into the sea and with ordinary care can give rise to no danger, while in hot countries he lives for a large portion of the twenty-four hours entirely in the open air.

On the other hand he is subject to a far greater degree of overcrowding and infinitely more trying temperature conditions than the majority of European dwellers ashore, while his supply of fresh water for ablutionary purposes is distinctly limited.

To illustrate the influence which these various features of the environment of the sailor have in the production or prevention of tropical diseases, these will be as far as possible considered according to their proved or supposed methods of conviction.

(*a*) *Diseases conveyed or supposed to be conveyed by Mosquitoes.*

The presence of mosquitoes on board a sea-going ship is a question that still needs observation, but so far as personal experience goes it has been noted that at places like Bombay where the ship lies half a mile from the shore, at Colombo where she is within 300 yards, and at Trincomalee where she is within a quarter of a mile of a shore abounding in these pests, very few indeed are found on board. The same applies to a great extent to flies, and these are probably conveyed largely by boats. I have noted large numbers of flies when near fishing fleets in China and also when lying off various Persian Gulf ports. In places like Rangoon and Calcutta, on the other hand, mosquitoes are numerous on board. The Panama Canal[1] sanitarians

[1] Journal of R. A. M. C., September, 1908.

appear to base their successful prophylactic measures on the assumption that the flight of mosquitoes is ordinarily limited to about a quarter of a mile, but no doubt, direction of wind, which at Colombo, for instance, blows almost directly ashore, has a good deal to say in the matter.

Malaria.—This freedom from mosquitoes is emphasized by the manner of occurrence of malaria in the Navy. Except for casual cases who can generally be found to have recently slept ashore, this disease is, judging from health returns and personal experience on the African, China, and East Indian stations, practically confined to landing parties for operations ashore, small ships serving up malarious rivers, etc., or lastly ships lying alongside or in dry dock in malarious ports. Outbreaks of malaria following shore operations have of recent years been greatly lessened as the result of the increased employment of native troops on the various coasts of Africa. Whatever too may be urged against the withdrawal of so many small ships from rivers, etc., from other points of view, there can be no doubt that so far as health is concerned the Navy has been a gainer, as is evinced by the most recent blue books. Such small ships as are left have been equipped with mosquito-net protection, but this in a ship of any size is an impossibility. Dry docking is, however, one of the principal causes of outbreaks now-a-days as is only too often illustrated on this station, which retains the unenviable distinction of the highest return for this disease. It is strongly urged that docking for any length of time in malarious ports should, where possible, be avoided, but it is needless to say that everything must be subordinated to the necessities of the service and that other palliative measures must therefore be sought for. I would submit as one of these the advisability of carefully treating beforehand all breeding places in the vicinity of the dock and as far as possible getting rid of adult mosquitoes. In my experience the latter largely take refuge during the day in the surface drains. To serve as a guide to successive medical officers and facilitate this, such a plan as that appended should be kept and added to as further breeding places or improved methods of treatment are discovered. The larvæ found should be bred out, identified, and their particular breeding place noted. Quinine in prophylactic doses should be administered and any malarial cases isolated by nets, while if the men, as at Bombay, live out of the ship, care should be taken that the protection they enjoy as a result is not rendered null and void by working in early morning or late evening. Non-observance of this rule has led to a severe outbreak. Hulking in a ship in the stream would be a great improvement. It is instructive to note that a certain prolongation of exposure appears usually necessary and that men casually sleeping ashore for a night comparatively rarely contract the disease. Thus the total for two years in the Hyacinth, exclusive of relapses, is 24, and all but 9 of these are attributable to living permanently ashore, shooting trips, stay in St George's Hospital, or have involved native members of the crew. The point has a certain value in the elucidation of disease suspected, but not so definitely proved to be mosquito-borne.

Another interesting feature of Naval cases is the almost invariability with which the first manifestations of illness follow putting to sea after stay in harbour.

Filiariasis.—The plan of Colombo dock shows that there were several carriers of filariæ (I found 6 infected out of 26), habitually on duty close to the dock at night and also that all the mosquitoes bred out and caught there proved to be C. Fatigans. There seems accordingly a distinct possibility that mosquitoes may have been present in which filarial embryos had undergone their cycle of development and, as a large proportion of the men were entirely unprotected and severely attacked by them for six weeks, that this would seem to offer a good opportunity for infection. An isolated observation of this sort has small value where the evidence it affords is negative, but the 121 men exposed during the entire period were examined sometime subsequently and none were found to harbour filariæ. The chief interest of the matter lies however in the fact that the docking of ships amid filariated populations is a comparatively common occurrence and that many Naval men, especially in times past, spent long periods in stationary ships, up rivers, and in shore appointments where they were correspondingly exposed, and yet, so far as I know, filiariasis is practically unknown. At all events Fleet Surgeon Bassett-Smith[1] gives evidence as to the rarity of its manifestations and in many hundreds of films examined at night, I have never once met with it, while the history of the 121 men referred to, as shown in Table I, shows that they are fairly representative of the Navy as a whole.

TABLE I.

Showing the length of service, &c., of the 121 men examined for Filiariasis.

Length of Service.	
Under 5 years	26
5 to 9 „	46
10 to 15 „	38
15 to 20 „	7
Over 20 „	4
Total ...	121

Number of foreign commissions served.

Only in the Hyacinth	26
One other foreign commission	31
3 or 4 „ „	47
Numerous „ „	17

Number of men who have served for lengthened periods in places and ships where the probabilities are that they have been considerably exposed to mosquito attack in the midst of filariated population = 29.

Although one must recognise that the life-history of the parasite as well as the weight of authority favour the view that infection is carried by the mosquito, the

[1] Journal of Tropical Medicine, 1st June, 1908.

disproportionate liability of Europeans (at all events those not permanently resident) and natives has always seemed a weak link in the chain of evidence connecting it with the actual bite. A notable contrast is provided by that unquestionably mosquito-borne disease malaria, a contrast all the more marked on account of the prevalence of filariæ-carrying mosquitoes as compared with the limited numbers of anopheles. It is true that Low[1] has shown that Europeans are equally liable, but personal observation and enquiry from those practising in the tropics would suggest that they are distinctly less affected by its manifestations. At the same time Low's observations show that they possess no immunity either to infection or its effects so that it is necessary to assume that a greatly prolonged residence is usually required before infection takes place, a fact that appears rather singular in view of the disparity in numbers already referred to between carriers of filariæ and malaria. An enquiry into the proportionate infection of natives at various age-periods would throw some light on this question of the time requisite and I submit the suggestion, if it has not already been investigated, to those who have the opportunity.

Yellow Fever.—The infrequency of this disease in the Navy also testifies to the comparative protection afforded from mosquito attack by life in a sea-going ship. With the exception of an outbreak in the training squadron in 1895 and in the ill-fated Condor in 1901, cases in recent years have been practically confined to persons living ashore in Jamaica or sleeping ashore while on leave or duty in other centres of infection. Obviously, in the light of present day knowledge, preventive measures resolve themselves into restriction of leave and mosquito protection while on shore duty in such ports, anchoring the ship out of reach of mosquitoes and, where an outbreak occurs, in prompt isolation of suspicious cases, destruction of mosquitoes on board and the old established Naval custom of sailing north.

Dengue.—A study of the occurrence of this disease in recent years brings out the following points:

Notwithstanding the fairly frequent presence of ships in ports where epidemics are raging ashore, outbreaks are comparatively rare and not infrequently isolated cases occur without spreading.

For instance, on leaving Hongkong, where the disease was prevalent ashore, in 1904, four cases occurred in my ship. I was myself one of those attacked and had just returned from two or three days in hospital where several cases were under treatment and I was much bitten by mosquitoes.

Further it is seen that the ships chiefly affected are either stationary ships (possibly from their permanent stay in centres of infection), or small vessels, as for instance in the epidemics of 1902-03 at Hongkong and Bermuda where the guardships suffered by far the most severely. If the larger sea-going ships are involved it usually follows a stay in a river port where the ship is alongside or anchored close to the shore. Instances are to be found in outbreaks in the Eclipse in 1898 after a stay at Karachi, in the Mildura in 1905 after a stay at Brisbane and several others. Again it has been noted that other ships, notwithstanding unrestricted intercourse, very often escape. These facts all offer evidence in support of the mosquito theory of infection, and the peculiarities in behaviour of seven-day fever, which is in my opinion identical with the form of dengue described by Craig and Ashburn in the Philippines, point in the same direction. In an outbreak last year it was, as usual, the crew of a ship in dock who suffered, other ships only had isolated cases, mere contact was obviously insufficient, there was no evidence in favour of food infection, and other features were suggestive of a mosquito-borne disease.[1]

(*b*) *Diseases conveyed by other biting Insects.*

Plague.—This is extremely rare in the Navy. On most stations the immunity enjoyed can readily be understood as ships are away from plague-infected ports, such as Hongkong, during the epidemic season. Curiously enough however it is on these less severely infected stations such as China and the Cape that Naval men seem to have been chiefly attacked, whereas in Bombay, where ships lie during the height of the plague season, large numbers of native are employed on board, and leave is practically unrestricted, cases are rare in the extreme. Last year an attempt was made to get all the natives in the squadron vaccinated against plague, but although the Seedies were all treated, neither the Goanese nor the Lascars would consent. Judging from the returns which were kindly sent last year by the Medical Officer of Health of Bombay, our men would appear to frequently sleep in parts of the town which these returns show to be infected and it would be interesting to know whether the European is considered to possess a relative immunity or merely to be less exposed. Naval experience would suggest the former to be the case. It would also be interesting to have figures regarding the prevalence of rat plague in merchant vessels lying alongside. There is no evidence of this occurring in men-of-war.

Climatic Bubo.—Buboes attended by a high degree of anæmia, considerable fever, and showing no very obvious cause for their presence are extremely common in the Navy, but although they are often seen at Hongkong and Bombay, they are even more prevalent at Zanzibar, where plague is unknown. I have found marked eosinophilia (in the absence of entozoa or similar cause) in several cases and some form of auto-intoxication with a source of irritation such as latent dhobie itch to determine the localisation of the bubo would appear to best explain the condition.[2]

Kala Azar and Trypanosomiasis for obvious reasons connected with geographical distribution are practically non-existent in the Navy, although Bassett Smith[3] has described one definite and three possible cases of the former and one case is returned from the Mediterranean fleet in 1907. There is no record of Trypanosomiasis

[2] Journal of Tropical Medicine, 15th February, 1908.

[1] Journal of Tropical Medicine, January, 1908.
[2] " " " " 1905.
[3] " " " " March, 1908.

or relapsing fever. The not uncommon presence of Cimex lectularius and of pediculi on board ship might lead to the spread of these diseases if once introduced.

Blackwater Fever may perhaps be conveniently referred to here although nothing definite is known as to its method of production. When Naval men were stationed in intensely malarious localities, such as the gunboats on the Zambezi and Niger, a few cases were returned, and I saw a few cases with hæmoglobinuria after the Benin expedition, but now-a-days they are practically unknown.

(c) *Food, Water, or Milk-borne Diseases.*

The comparative infrequency of the diseases classed under this head, Typhoid, Dysentery, and Cholera, illustrate the already mentioned advantages possessed by the modern sailor during his sojourn in tropical waters, with regard to food, water, disposal of excreta, and protection from flies and similar carriers of infection. He is, of course, exposed to risk when ashore on leave but this is considerably lessened by the fact that he is not as a rule inclined to waste much money on food and that his drink in the majority of cases is confined to beer.

Typhoid Fever.—Excluding outbreaks resulting from shore operation such as in S. Africa and China, the rate per 1,000 total force for this disease has not exceeded 3 in the last sixteen years and is now below two, a considerable proportion of which is contracted while living ashore on the Home station.

The frequency with which outbreaks of any magnitude have followed the use of shore water is a striking feature of the manner of its occurrence and, in at least two instances, the Vulcan in 1900 and Fearless in 1904, specific contamination of the tanks has actually been proved, although in the majority this vehicle of infection is said to be excluded by the evidence. Such was the case in one of the most extensive outbreaks of recent years, the Cambrian in 1903 although its explosive character and generalised distribution were very suggestive of a water epidemic. In my own ships during four years on this station and China, both bearing an evil reputation in this respect, condensed water and boiled milk have alone been used and only two definite cases have occurred, both on this station, both following in successive years a stay at the Diyatalawa camp, and both giving a history of eating watercress.

That milk plays no small part is suggested by several facts. In numerous small outbreaks officers, who are usually the only persons supplied with fresh milk on board, have been exclusively affected. Thus in the Arrogant, Canopus, Ocean, Albion, Arethusa, from 4 to 6 officers alone suffered, while a rather more extensive outbreak in the Barham was actually traced to the use of milk by the men and in others it was suspected. It is true that in most cases the milk was said to have been boiled, but my experience on the Malta Fever Commission has shown that the existence of the strictest orders to that effect by no means ensures its effective execution. Moreover Table 2 shows that to some slight extent there is a correspondence between bad and good years for Typhoid and Malta fevers in the Mediterranean, while my Military colleagues on the Commission, Majors McCulloch and Weir, R.A.M.C,[1] noted something similar in the Army in Malta and also some correspondence in prevalence in different units.

TABLE 2.

Year.	Enteric fever.		Malta fever.	
	Cases.	Ratio per 1,000.	Cases.	Ratio per 1,000.
1897...	122	10·23	546	45·6
1898...	20	1·57	359	28·31
1899...	21	1·54	195	14·5
1900...	59	4·14	317	22·24
1901...	31	2·2	252	17·91
1902...	59	3·19	354	19·16
1903...	26	1·41	339	18·41
1904...	61	3·11	333	16·99
1905...	50	3·48	270	18·8
1906...	29	2·39	145	11·95
1907...	28	2·65	14	1·32

The existence of Typhoid carriers in the Navy has not, so far as I know, yet received attention but might easily be the cause of sporadic cases while a distinct danger would appear to exist in the possible employment of such persons to clean out the water tanks, where they are inside in a practically nude condition.

Suggestions for prophylaxis.—The maintenance of the purity of the water supply by the exclusive use of distilled ship's water conflicts on distant stations, where coal is very expensive, with the provision of unlimited fresh water for ablutionary purposes, a very real need in the Navy. Nevertheless nothing should be done to imperil the purity of the drinking water, and it must be remembered that in the supply of water to ships not only has its freedom from contamination at its source to be taken into account but also the risks to which it is subject during its conveyance on board. Judging from personal experience of floating water tanks in many tropical ports this is by no means small.

Shore water for ablutionary purposes might however be carried with safety if a series of separate tanks and supply and distribution pipes were fitted, provided precautions were taken to ensure its use solely for its intended purpose and I submit this suggestion. At all events experience of previous outbreaks teaches the necessity of thorough sterilisation of any water tank made use of for the purpose before again admitting ship's water.

Milk should either be entirely forbidden (perhaps the safest plan), or else boiled and the resultant fluid tested daily with the ortol and peroxide test, which procedure is now enjoined in the East Indies station orders. The use anywhere in the East of watercress, shore ice in drinks and shell fish unless from sources above suspicion, should be prohibited on board, and of lettuce, spring onions

[1] Reports of Med. Fever Commission, Vol. VII, p. 142.

and similar vegetables discouraged, and, if allowed, the strictest orders given about washing them, while no hawkers of food or drinks should be allowed on board or alongside. The men should also be warned as to their use ashore. Danger from aerated waters is largely obviated by the installation of a mineral water factory on board as is now frequently the case. All recent Typhoid cases should be prevented from handling food or drinks for their messmates, and from cleaning water tanks, while their limited numbers suggest the possible advantages of temporary segregation and bacteriological examination of fæces and urine, as is done in the Army in India.

Dysentery.—Like typhoid this disease is quite uncommon in the Navy except as a result of shore operations and the China station is chiefly responsible for such cases as do occur. In four years in China and East Indies stations I have only seen six cases among about 1,300 men showing any signs suggestive of this disease, and, in all these were by no means definite and of the mildest character. Most of the precautions alluded to apply to dysentery and cholera as well.

Liver Abscess.—The supposed connection of this condition with dysentery makes this a favourable opportunity for referring to it. Unfortunately no very definite information can be obtained from the blue books with regard to its prevalence, but personal experience and such details as it is possible to glean would suggest that it is by no means uncommon. Thus from the occasional mention of a fatal case and the list of operations at the various hospitals it is possible to collect 50 actual cases and 7 negative explorations in the last six years and these (although doubtless understated) are compared in Table 3 with the total number of dysentery cases recorded during the same period and contrasted with the figures given in the British Medical Journal by Sir Havelock Charles.[1] Possibly some of these were not true tropical abscess but a more reasonable criticism is to be found in the possibility that some of the numerous cases recorded as diarrhœa were really dysentery and as a matter of fact the only case of hepatic suppuration which has occurred in the Hyacinth was preceded by what appeared to be an ordinary but rather obstinate diarrhœa without any dysenteric symptoms at all. It is, too, my impression that China, which provides most of the dysentery cases, is also chiefly responsible for liver abscess but nevertheless, so far as the facts go, they would appear to favour the contention that some other and more important factor is necessary.

TABLE 3.

—.	Dysentery cases.	Liver abscess cases.
Native Army	23,516	72
Prisons	45,352	42
British Army in India	5,581	860
Navy	550	50

[1] British Medical Journal, 1908, Sir H. Charles.

Cholera.—With the exception of an outbreak in a ship at Bombay in 1891 only isolated cases have occurred.

Malta Fever.—Table 2 illustrates the extent to which this disease levied toll on the men in the Mediterranean fleet and also the degree of diminution effected by the simple precautions adopted with regard to the use of milk. In only one of the 14 cases recorded in 1907 was milk said to be definitely excluded and I should be inclined to doubt even that.

(d) *Infective Granulomata.*

Diseases such as leprosy and yaws are practically non-existent in the Navy although an occasional case of the latter is seen among the Kroomen on the Cape station; in treating one of whom a medical officer became inoculated some years ago. Oriental sore is however fairly often seen in the Persian Gulf ships and the Medical officers of these may be able to throw some light on its causation.

(e) *The effects of Climatic Influences.*

As might be expected heat-stroke and allied complaints are common more particularly in ships traversing the Red Sea in the summer. Steam trials in the tropics are also responsible for a good many of the minor effects of heat occasionally heat exhaustion but far more frequently, in my experience, a pyrexial condition lasting two or three days or more. Another common condition among stokers as the result of trials is a condition of gastric irritability with pyrexia, resulting from drinking an excess of fluid and either occurring alone or, where vomitting is severe, combined with muscular cramps, due probably to loss of moisture and consequent stimulation of the nerve endings.

Another condition which is not uncommon and appears to be chiefly the effect of climate, is a pyrexia of some four or five days duration attended with foul tongue and breath and constipation. This attacks youngsters during their first hot spell and seems to be due to auto-intoxication as a result of too nitrogenous a diet combined with sluggishness of the abdominal organs.

(f) *Abdominal Diseases.*

Diarrhœa is one of the commonest causes of temporary disability on the China station but is easily got rid of. Sprue on the other hand is very rare. I have only seen one case in a man, although it would seem to be rather more prevalent among officers.

(g) *Other Animal Parasites.*

The commoner intestinal parasites, such as Ascaris and Tricocephalus are harboured by a large proportion of the men on the China station. Of 100 men suffering from various intestinal ailments, I found Ascaris in 28, Tricocephalus in 2 and both in 3; but among officers only one was infected out of about 15. In more than one case, their presence was associated with symptoms suggesting Appendicitis and in all the well-marked instances of that disease that I saw out there, they were

present in number suggesting a casual connection.[1] Tape worms, more particularly T mediocanellata, are also not uncommon, but Ankylostomiasis is practically never seen in the Navy, although there was an outbreak in 1904 among the Kroomen at Ascension. Nor are other parasites such as Bilharzia or Guinea-worm any more prevalent.

(h) Diseases of the Skin.

From the overcrowding, limited supply of fresh water for washing, high temperature conditions, and excessively nitrogenous diet, it is only to be expected that certain skin ailments should be extremely common and their prevalence is quite in accordance with anticipation. Prickly heat is, of course, practically universal to a greater or less extent, and on this station and China, Pemphigus Contagiosus is frequent and troublesome. In the Hyacinth about 50 men have been attacked each year by the latter, and like prickly heat it is apt to be followed by crops of boils. Certain stations, such as China, are however even more troubled by boils and carbuncles, while the Aden division of this station appears to have a particularly evil reputation in this respect. That the lower deck conditions already referred to have a good deal to do with their causation is shown by the almost complete immunity of officers, the principal vehicles of infection being, in my opinion, infrequently changed underclothing and towels.

Prophylaxis.—Increase of facilities for washing both the person and underclothing among the men is one of the chief desiderata, and a suggestion has already been made with regard to the supply of shore water for this purpose. It is a question whether the fitting of shower baths in ships' bath-rooms would not be found more satisfactory and economical than the present baths; they have been found so, I believe, by the Americans in Panama. Equally important are the frequent changing, cleansing, and airing of bedding, towels, and underclothing.

General Diseases of undetermined Nature.

Beri-beri.—There are two foci for this disease in the Navy. Ascension Island where the Kroomen are attacked, and the Persian Gulf ships where it involves Europeans as well as natives. So far as Ascension is concerned, alterations in the dietary and careful inspection of new arrivals seem to have had a great effect in reducing the incidence of the disease as there was only one case in 1903 and none since that year, as opposed to 60 in 1902, 43 in 1901, and 94 in 1900.

[1] Journal of Tropical Medicine, February, 1904.

In conclusion, I venture to express a hope that although it is to be feared that very little positive information of any value can be gleaned from this superficial study of the occurrence of tropical diseases in the Navy, it may at least promote discussion and elicit opinions from those who have a greater practical experience upon which to found them.

DISCUSSION.

Captain H. W. Jones, U. S. Army Medical Corps, said that the subject of mosquitoes on Naval vessels was of great interest to him. Although he was unable to state whether or not mosquitoes were commonly found on American Naval vessels, he was in a position to state that they were very rarely found on American sea-going troopships plying between San Francisco and Manilla, even if the vessel lay very close to shore when docked not more than fifty yards off. For this reason he was of opinion that mosquitoes did not fly far out to sea and it appeared that even vessels lying a short distance from shore would be safe from epidemics of malaria, dengue, &c. Of course mosquitoes if present must be kept from breeding, but this did not present difficulties on boardship. He desired to know whether pilgrims were vaccinated before embarking.

Dr. Turner stated that every pilgrim before embarking should be vaccinated or show that he had been recently vaccinated.

Lt.-Col. Crimmin said that he persuaded the Hajees to be vaccinated by saying, those who were vaccinated first would go by the first steamer.

Dr. Bawa, Health Officer of the Port of Colombo, spoke to the action taken in regard to persons going to Ceylon *via* Tuticorin. He said that unless persons showed signs of recent vaccination they were turned back and not allowed to enter Ceylon.

He wished to know whether provision is made on Naval ships for the isolation of infectious cases or whether the isolation was extemporised for the occasion.

Fleet Surgeon Clayton said that the provision of isolation depended very much on the Medical Officer. He believed in isolation in a boom boat or a sick bay which every vessel had or should have, or isolation could be effected right forward in the forecastle. He had used the boom boat with great success. This was possible in the tropics where the weather conditions were different to those in Europe where a sick bay was a necessity. If necessary it was possible to isolate cases and treat them in different parts of the ship.

THE CARRIAGE OF PLAGUE BY SEA.

Some Suggestions for Preventive Measures to be adopted in Docks and on Boardship, with special reference to Bombay.

By G. J. BLACKMORE, M.D., D.P.H.,

Formerly Assistant to the Port Health Officer, Bombay.

The history of the prevailing pandemic proves that almost without exception the countries at present infected have become infected through their ports. This is clearly brought out by noting the places primarily affected. Beginning in China the disease spread to Hong-Kong probably from Canton; India became infected at Bombay; Arabia at Jeddah; Egypt at Port Said; Turkey at Constantinople; Italy at Naples; France at Marseilles; Great Britain at Glasgow and London; South Africa at Cape Town; North America at San

Francisco; South America at Rosario; Australia at Sydney; the world has in fact been infected by sea, and if further spread is to be prevented it is in the ports and on boardship that preventive measures must be taken.

It is now established beyond all doubt that man receives his infection from the rat by means of the rat flea, and measures to prevent the spread of plague by sea must therefore be directed against rats, fleas, and infected human beings. Hitherto the measures adopted in Bombay have concerned themselves almost entirely with the spread of plague by human beings. Now, although numerous cases of plague are known to have been introduced into uninfected countries and many more must certainly have escaped detection, I have never heard of any case, and do not think one has been recorded where the introduction of plague by a human being into an over-seas uninfected country has ever been the starting point of an epidemic. If epidemics had begun in this way they would not invariably have started in ports as they have done, but would, in a certain proportion of cases, have appeared in the interior of the country. It is thus evident that measures directed against human beings alone are not likely to be very successful in preventing the spread of plague. The rat is undoubtedly the essential factor in the carriage of plague by sea, and if the transmission of plague is to be prevented some means must be devised of either preventing rats from gaining access to ships in infected ports, or the rats must be destroyed on board the ship after it has left such ports. The destruction of rats is the one measure of supreme importance and the docks of infected countries are the places in which it should be most systematically carried out. Bombay is at the present time, and has been for some years, the great plague distributing centre of the world, and it is here that the greatest activity should be displayed in destroying the known carrier of plague. I regret to say that up to the present no attempt of any kind in this direction to limit the spread of plague has been made.

Before speaking of the methods to be adopted in dealing with rats it will be well to say a few words about the transmission of plague by means of human beings and fleas.

The attempt to prevent the carriage of plague by human beings is, of course, advisable, as such persons may be the means of starting an epidemic among the rats on boardship, or at the port of arrival, although I think the risk is not great.

This measure is, as I have said, the one to which most attention has been paid in Bombay, and the method of examining in force here must be considered to be very efficient, as I do not think any case of plague, excepting in the incubation stage, has ever escaped detection, and by a rigid exclusion of temperature cases, surprisingly few cases of plague have ever been allowed to leave this port. The method adopted is to examine carefully for buboes, for temperature, and for the general signs associated with an attack of plague. Special attention should be paid to temperature. It has been repeatedly proved in the Port Health Camp at Bombay, that many persons who have contracted plague have a marked rise of temperature even as long as two or three days before any other symptom of plague shows itself. If the examination is carefully made by experienced medical officers there is then very little risk of a case of plague being allowed to leave the country.

The carriage of plague over seas by means of fleas appears to be so unlikely that it is questionable whether it is necessary to take any steps to prevent it. I know of only one case where clothing was suspected of being the cause of a case of plague in an uninfected country, and that was a doubtful case. It is the custom in Bombay, and has been for several years to disinfect the clothing of persons leaving for places out of India, but with our present knowledge we know that this measure can have been effective only in so far as it was effective in destroying fleas—disinfection of clothing for the purpose of destroying germs, and it was for that purpose it was done—would appear to be unnecessary. Even this disinfection has been only partial; it has been the custom to exempt the clothing of all saloon passengers whether European or Native; of all officers and engineers whether European or Native; and of all European sailors. It is certainly very difficult to understand a regulation which permits a native officer or engineer on a vessel to take his clothing away without disinfection, while native sailors on the same ship have to be disinfected although the officers and engineers come from the same parts of the town and live under the same conditions as the sailors. Notwithstanding this merely partial disinfection of the clothes, and the fact that no steps have been taken to deal with the vermin on the bodies of persons leaving Bombay, no case of infection traceable to clothing from India has, I think, ever been proved to have occurred in another country. It cannot be contended that the disinfection as carried out here has been responsible for this result. It seems therefore that there is no real benefit to be derived from doing anything to the clothing of persons leaving India by sea. If, however, it is still considered that there is risk of spreading infection by means of clothing, then all clothing should be dealt with, and the object to be aimed at should be the destruction of fleas, not the destruction of germs. The use of saturated steam is probably an effective way of dealing with fleas, and would allow of the present disinfecting apparatus being used, but there are certain difficulties and disadvantages in the use of steam; certain articles, such as boots, are destroyed if subjected to its action, and others are more or less injured. A difficulty also arises in the case of clothing belonging to certain crews. On a P. & O. vessel, for instance, much of the clothing is white, and has been washed, starched, and ironed ready for use on board the vessel; to put such clothing through a steam disinfector means that it would not be fit to wear until it had been again starched and ironed, but there are no facilities on boardship for this kind of thing.

Even if this clean clothing is not likely to harbour fleas—and it all comes from infected parts of the town—it is often mixed with dirty clothing. It would therefore be of great advantage if some other method than the use of the steam could be devised for dealing with clothes, some method designed with the sole object of destroying fleas, and which would admit of all kinds of clothing and boots being treated without the clothes or boots themselves being affected in any way. Sulphur vapour would probably be quite effectual if all clothes were hung up separately in a closed chamber, but it would take several hours, which is a serious, if not insuperable, objection to its use, and it would probably not be of much use in the case of mattresses. At present there appears to be no gaseous substance quite suitable for the purpose. The vapour of hydrocyanic acid was tried some years ago and gave promising results, but the experiments were not followed up. On the whole the use of steam for most clothes and of sulphur or formaldehyde for clothes which cannot be steamed, and for boots, would appear to be the best available method of ridding clothes of fleas. If clothes are dealt with the boxes in which they are carried should also be treated. In Bombay these boxes are washed and scrubbed under a tap and are then swabbed with a disinfectant. It would probably be a quicker and more effectual method to insert the empty box over a steam jet for a moment or two, in the way employed to disinfect milk cans in England. If, however, the swabbing method is continued it would be better to employ kerosene oil emulsion than the disinfectants now in use. In the case of Bombay where crews' clothing is practically always carried in boxes I am inclined to think that the cleaning of boxes and swabbing them with kerosene oil emulsion might, without risk, be substituted for the disinfection of the clothes carried in the boxes.

The one essential measure—and the one so strangely neglected in India—remains to be discussed, *viz.*, the destruction of rats in the docks of infected countries, on board vessels sailing from those countries, and in the docks of uninfected countries in which such vessels are to be ultimately berthed. The attempt to prevent rats from passing on to ships lying alongside wharves or dock walls must, I think, be confessed to have failed, and it is difficult to conceive of any really effectual measure which would at the same time allow the ordinary loading and unloading work to be carried on unhampered. Even if rats could be prevented from passing on board themselves a certain number would be carried on board in cargo and baggage. If, however, there were no rats in the docks, none could gain access to the ships excepting the few that might be in articles of cargo. There can then be no doubt whatever that even if measures are not taken to free infected ports of rats, at least every effort should be made to rid the docks of them. and with properly organised, persistent and systematic efforts, the attempt should meet with such a measure of success as to render the exportation of plague very improbable.

The first essential is a properly trained and equipped rat-destroying staff, whose sole work should be to attempt to keep docks free from rats; spasmodic efforts by untrained men are quite useless, the war against rats, if it is to be successful, must be carried on continuously and relentlessly. There are various methods in use for destroying rats, and the chief of these may be indicated :—

1. By the use of traps.
2. By making use of the natural enemies of rats, such as dogs, cats, and ferrets.
3. By the use of poisoned food.
4. By introducing a fatal infectious disease among the rats.
5. By using poisonous or irrespirable gases.

Traps.—The use of traps is often attended with rather disappointing results, mainly because no particular care is usually taken when using them. In skilled hands, however, I have known large numbers of rats to be accounted for by means of traps. Wire traps which will hold several rats at the same time are probably the best; they should be handled as little as possible and plunged into boiling water immediately after rats have been removed from them in order to keep them free from odour. The baits should not be touched by hand and should be changed frequently; those most acceptable to rats appear to be toasted cheese, oatmeal, sunflower seeds, and herrings; or bread and other substances on which a few drops of oil of aniseed or oil of rhodium have been sprinkled. One bait will often succeed in enticing rats into a cage when others have failed. Cabbage leaves on which oil of aniseed or oil of rhodium has been sprinkled are in great repute in some ports, but I have been rather disappointed in the use of these oils. I have obtained the best results with sun-flower seeds.

Dogs and Cats.—Trained dogs in the hands of proper rat catchers are of undoubted use, and are much employed. It is doubtful, however, whether the use of cats has received the attention it deserves. Buchanan has ably advocated their employment and they are certainly well worth a trial in docks.

Ferrets.—These animals are used constantly in some places, but it is doubtful whether they should be employed in places where rats are infected. In the only case in which I used them the animals quickly contracted a disease closely resembling plague in its symptoms, post-mortem appearances and the bacilli found in the organs, but definite proof of this disease being plague was not obtained. I heard, however, of other ferrets employed in hunting plague rats dying of the same disease.

Poison.—This is a most useful method of destroying rats. The disadvantages of using poison are obvious: most rat poisons will kill other animals and many persons object to their use on this account, but if care is used the danger can be reduced to a minimum. By laying the poison at night and taking up what is left early in the morning, there is practically no risk of anything but rats suffering from its employment. Another disadvantage is that rats killed by poison often die in inaccessible places and the stench arising from their decomposition is unpleasant. There appears to be no way

of avoiding this. Some makers of rat poisons advertise that their poison causes the dead bodies of rats to dry up without emitting any offensive odour, but a poison which really does this has not come under my notice. The only reply that can be made to the objection that poisoned rats cause such an objectionable odour is, that the odour from dead rats about a place is much less dangerous than the presence of live rats in it when plague is present in the town or likely to be introduced. Most of the advertised rat poisons fulfil the purpose for which they are sold fairly well and some of them give excellent results. A home made preparation which is highly spoken of is one made by mixing equal parts of plaster-of-Paris and oatmeal together. The addition of a drop or two of oil of aniseed probably makes the mixture more attractive. Whichever poison is employed it should be spread on small baits untouched by hand and these should be used systematically and regularly in all places frequented by rats, not omitting sewers and drains.

The Introduction of Infectious Diseases among Rats.—So many contradictory reports have been published regarding this method of killing rats that it is very difficult to estimate its true value. I have tried the method with Danysz's bacillus, but the results were not decisive, and inoculation experiments seemed to show that the cultures had lost much of their virulence, a common occurrence which has been the cause of many failures. When Danysz's bacillus was first introduced it was thought that the disease if produced would spread rapidly from rat to rat, but it was found that infection took place apparently only when rats that had died, or were badly infected by the disease, were eaten by their fellows. Rats shut up together in a cage will sometimes eat one another, and they possibly do so to a limited extent under normal conditions, but it is quite obvious that a method relying solely on this proclivity to cause the spread of the disease was destined to failure ; especially when it is considered that when the disease is propagated in this way the organism rapidly diminishes in virulence, and those animals which contract the disease and live, as many do when infected with a weak organism, are apparently immune from the disease. Even if the disease had been more easily disseminated it is doubtful whether it would have been of more than limited use. Plague is one of the most deadly rat diseases known, but I have never heard of its exterminating rats in any place. If Danysz's method is to be efficacious no reliance must be placed on the spread of the disease from rat to rat, but arrangements must be made so that each rat receives its dose of fresh virulent culture. This is done by distributing small pieces of bread or crushed oats soaked in a broth culture of the organism. Probably many of the early unsuccessful results were due to defective technique, and much better results have since been obtained. Danysz reported in April 1904 that a summary of the reports he had received and which numbered several thousands showed that in 60 per cent. of the operations undertaken the rats completely disappeared, in 15 per cent. the results were negative, and in 25 per cent. partial destruction was effected. In the same report he gives particulars of the results obtained in Odessa, in September and October 1902. The operations were directed by the Director of the Pasteur Institute of Odessa, and he lays special stress upon the need for proper and systematic distribution of the inoculated crusts, and of the necessity of using the infected broth the day it is made. Several weeks after the operations had been carried out the Bacteriological Institute was able to procure only 14 rats alive and in good health, although it offered a reward of 15 kopecks a head.

In the French Chamber of Deputies complaint was made about the end of 1903 of the immense damage done to crops in certain constituencies by the rats. It was decided to try the effect of Danysz's virus. The operations were under the direction of Dr. Roux and were begun on 28th January. On 24th February he reported that the campaign had been completely successful. It is estimated that 95 per cent. of the rats were slain, their dead bodies were found in the holes in heaps of 15 and 20. These results are encouraging. But to ensure success it is necessary that the cultures should be of full virulence and fresh. Unfortunately cultures seem to lose their virulence by being transmitted by sea, and it is not easy to exalt it again. Most observers state that the virus is harmless to those who handle it and to all animals other than rodents. Although this has been recently disputed it would appear that there is no risk if reasonable care is employed in handling it.

Poisonous Gases.—The two gases chiefly employed are sulphurous acid gas and carbon dioxide. On land these gases can be used in sections of sewers, otherwise they are more useful for destroying rats in ships.

The foregoing are the chief measures which may be used in docks for destroying rats, others designed to drive them away are useful, such as the employment of lime and carbolic acid, and the pouring of tar and sulphuric acid into rat holes.

Destroying Rats in Ships.—Hitherto no serious attempt appears to have been made to destroy rats on ships as a prophylactic measure, although it is a measure of vital importance if uninfected places are to be saved from a visitation of the disease. All the methods already mentioned can be made use of on board ships, but the one of greatest efficacy is undoubtedly the use of poisonous gases. It is not necessary to discuss the use of CO_2. It has the advantage of not being injurious to merchandise, but it is uncertain in its action, costly, and dangerous. Sulphurous acid gas is cheaper, safer, more convenient, and probably more efficacious. It has given excellent results and is now in general use. The gas may be produced by burning sulphur in the ordinary way, or it may be generated in a Clayton apparatus. The latter is simple, easy to use, and the production of the gas is comparatively inexpensive. The apparatus is taken to a vessel on a barge, and sulphur is burnt in a receptacle connected with a furnace. From this receptacle flexible pipes can be led to any part of the ship, and to several parts at the same time. A powerful fan

forces the gas through the pipes, and at the same time an exhaust fan withdraws air from the hermetically sealed holds, &c. The air from this exhaust can be tested from time to time to ascertain the percentage of SO_2 present. By this method the generation of the gas can be carried on without fail for any length of time. Many observers have reported on the efficacy of the Clayton apparatus. Its efficacy is not so marked when there is cargo in the hold, and especially if there are woollen or other fabrics done up in tight bales, as these fabrics possess a peculiar power of absorbing the gas in their outer layers. Metals are tarnished by the gas, but might, I think, be protected by applying a little grease or oil. Certain food stuffs are rendered unfit for consumption by absorption of the gas. I have not found that the decorative work in the saloons of steamers is injured.

When the Clayton apparatus is not available, burning sulphur in the ship can be resorted to. I have found that the best way to do this is to use a charcoal brazier which is something like a bucket on short iron legs. This vessel is half filled with glowing charcoal and the necessary quantity of sulphur placed on top. These braziers are convenient and safe. They can be carried about by a handle, any number of them can be used in any part of a ship, and the use of the red hot charcoal ensures the complete combustion of the sulphur, while adding CO_2 in addition to SO_2 to the atmosphere. To ensure the complete destruction of rats in a ship, the ship should be completely sealed up including the funnels and the whole done in one operation; otherwise rats make their way from the parts being fumigated to those not yet done, and return to the first part when the fumigation of the second is being carried out.

If the destruction of rats in infected docks were thoroughly carried out, and vessels while in those docks were claytonised, I do not think there would be much chance of infected rats being carried. Still there are certain parts of a ship difficult to deal with by means of gases, such as the upper cabins, and the open decks; it is therefore advisable in addition to the use of gas to make use of traps, poisons and cats.

In conclusion, there can be no doubt that the destruction of rats in docks and ships is an essential measure if plague is to be prevented from spreading. While the rat, the real carrier of plague, is permitted to pass without let or hindrance from infected to uninfected countries, is indeed knowingly carried from place to place, it is both foolish and useless to continue those measures for preventing the spread of plague which have been used in the past, and which, as the present pandemic only too conclusively proves, have utterly failed to achieve their object.

DISCUSSION.

Lt.-Col. Crimmin, in remarking on the foregoing paper, said that the chief recommendation in the paper just read appeared to be that ships leaving plague infected ports should have the rats on board killed before or after departure or before arrival at another port. Dr. Blackmore would, he knew, be pleased to learn that since the speaker last had his valuable assistance in the Port over 3 years ago steps had been taken to protect ships against the ingress of shore rats. All ships in Bombay were now kept 3 feet off the dock wall by means of specially constructed fenders, their ropes and hawsers were protected by metal discs of an approved type, and the gangways when down were freshly tarred. They offered to free all ships of rats, cockroaches, &c., by means of sulpur dioxide gas generated in a Clayton apparatus which was capable of saturating 250,000 cubic feet of space per hour with a germicidal or vermin destroying gas. All plague infected ships had to be Claytonised before they could obtain a Bill of Health, and all pilgrim ships had to be freed from rats by the same process before pilgrims were taken on board. In the Port of Bombay the Claytonising of ships was done free of charge with the exception that the sulpur required for the process had to be provided by the ship.

Capt. H. W. Jones, Medical Corps, U. S. A., stated that, during the recent anti-plague campaign in San Francisco, the methods directed against rats on ship board were that on arrival each ship was promptly given the sulphur dioxide treatment, the hatches being battered down and made tight. During stay in port all ships were required to be kept six feet from the dock, and rat guards at least 18 inches in diameter of galvanised iron, were kept on all hawsers. In addition the gangways were required to be hoisted at least six feet from the dock. If those measures were not carried out a bill of health was denied. Just how successful the sulphur treatment proved he did not know, but on the ship on which he was stationed but few dead rats were ever found. How thorough or extensive were the measures taken to destroy rats about the various docks he could not say although he knew that those engaged in the anti-plague campaign were thoroughly convinced of the necessity of the realization, on the part of the public, of the importance of rat destruction.

Dr. Bawa said he would urge, in support of Dr. Blackmore's contention, that plague was conveyed across the sea by rats, the remarkable immunity of Colombo from plague infection. Whilst all the tropical ports of any importance had had indigenous plague, Colombo had preserved a remarkable immunity. The port of Colombo had no docks or wharves (except the new dry dock in which special and elaborate precautions were adopted) and it could be assumed that no rat, infected or not, would undertake the voyage from a ship in mid-stream to shore in a cargo lighter. Disinfection of all soiled linen disposed of all possible flea convection, and as for human convections, the careful and systematic examination of all passengers and crews could always be relied upon to prevent the introduction of plague by direct contact.

Fleet Surgeon Clayton enquired whether there were any records of rat epidemics, and if the epidemic among the rats was followed by plague among human beings on board ships.

Dr. Blackmore in replying stated that his main theme was that docks in infected countries should be freed of plague, and he thought that the Bombay Port Trust had scarcely done its duty in that respect. He had always thought that Colombo owed its immunity from plague to the fact that it had no dock walls against which vessels could be berthed.

In reply to Dr. Clayton the writer of the paper stated that he had personally investigated many epidemics of plague among rats on boardship which had been followed after a definite interval by plague among the human beings on board.

HYGIENIC NOTES ON DOCKING AT MUTWAL, COLOMBO.

By F. H. A. CLAYTON, M.D., M.R.C.P. (Edin.),

Fleet Surgeon, R.N.

MOSQUITO BREEDING PLACES.

Surface Drainage.—There are two systems of surface channels on either side of the dock, one close to it and discharging into chambers covered in by square iron covers, the other some twenty yards or more from the dock and discharging into similar chambers through gratings. Between these on either side is the drain into which they eventually discharge and which has four inspection chambers at each side, shown in the plan at (C). All the chambers referred to are of much the same type although differing in size and are apparently devised to separate the solid matters as the discharge pipe opens about a foot above the bottom of the chamber, thus leaving a stagnant foot of water in which the solid matter sinks. This provides an admirable breeding place for mosquitoes although necessarily it is the more accessible chambers covered with open gratings that principally act in this way as is shown in the plan.

From their narrowness and depth it was difficult to bale these out and the most convenient method of dealing with all these was found to be by pumping them out. For this purpose a garden pump (price 10 rupees) was purchased by me at Brown and Co.'s which has the suction opening at the bottom and the discharge pipe at the side and pointing up at an angle. A plate was fixed to the bottom to stand on and help to keep out mud and a length of hose was fitted to the discharge pipe. With this the chambers could be readily almost entirely emptied and the bottom was then dried with a cloth and once now and then lime-washed. All were attended to weekly thus entirely preventing the breeding of any more mosquitoes.

The surface channels are also very badly laid and require occasional sweeping down as otherwise they become blocked by refuse and collect stagnant water.

Steam Capstans and Cranes.—There are steam capstans at the head of the dock, and alongside the entrance, and a large crane is also being fitted at the head of the dock. Water collects under these and it is necessary to keep them under constant observation although on the present occasion no larvæ were ever found there. I have however found them at Malta. There are also possible breeding places in and around the caisson.

Casual collections of Water.—Last year old casks and tins abounded and in several larvæ were found, but this year there were not so many. They are scattered all over the place and require searching for. They were dealt with by turning bottom up or breaking.

At the head of the dock there was much casual water in connection with the steam crane which was being erected. Parts of this swarmed with larvæ, and it was dealt with partly by oiling and partly by emptying. There was also much water on the sea side of the pump house where works were in progress. This was partly salt and no larvæ were found.

Water in dock itself.—At the head there were some shallow pools left by the removal of some of the keel blocks and much weed grew in the tins at the sides so that it is a wise precaution to sweep these out weekly although no larvæ were ever found there.

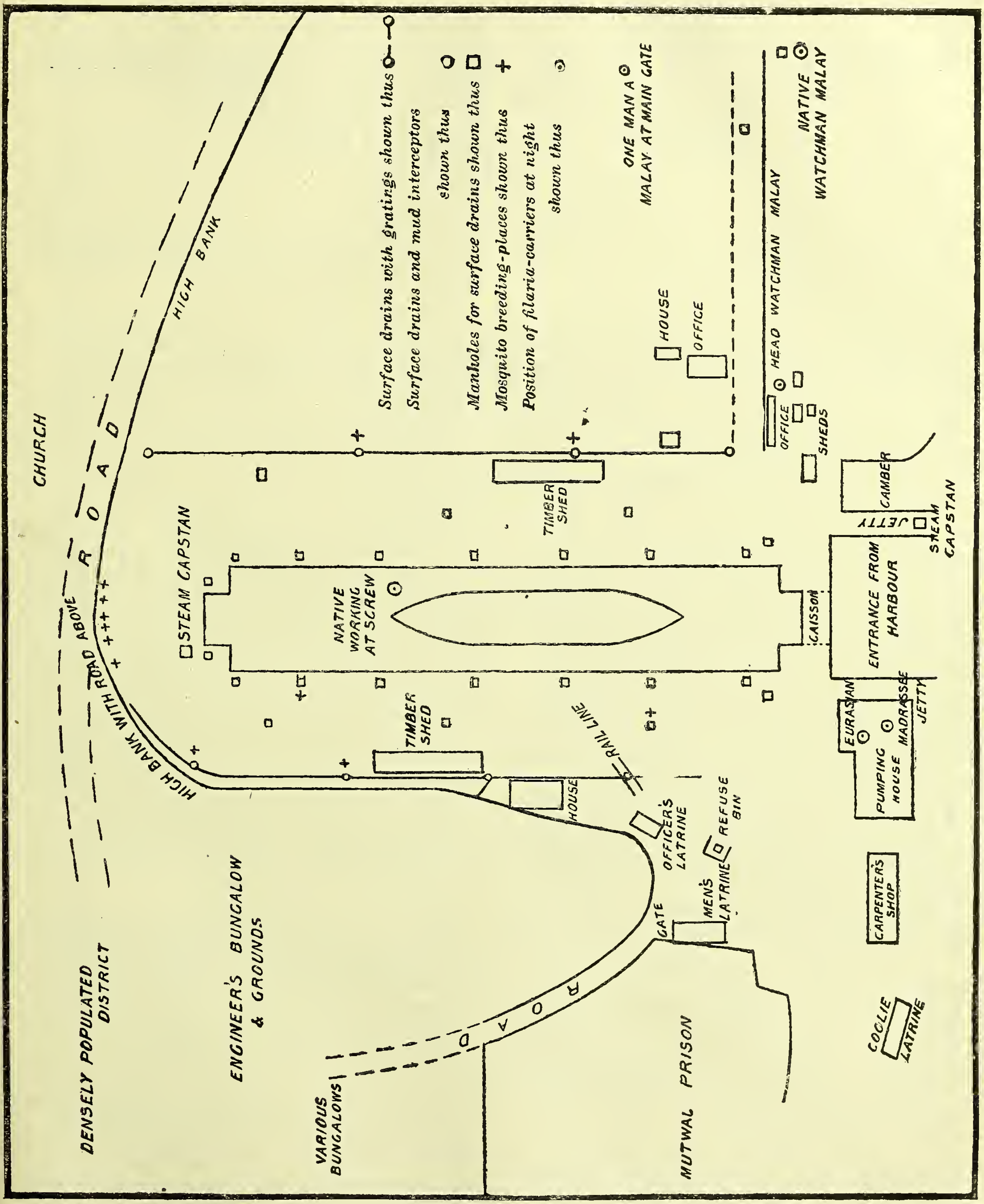
Latrines and Refuse Bin.—There is a large coolie latrine about 150 yards from the dock which is in constant use. As it is more than probable that some of the numberless coolies are passing highly infective excreta, this is a quite possible source of infection by flies which must therefore be as far as possible prevented. I believe that in May—July, 1907, a ship called the Trowbridge, which was then in dock, had a severe outbreak of typhoid.

Both officers and men's latrines are, in my opinion, insufficiently supplied with earth, and the latter is not often enough cleared ; as far as could be ascertained this was only done once a day. This and also the refuse bin require disinfecting pretty frequently or they attract flies. There is, however, a great improvement in the manner of refuse removal this year, as last year it was left fermenting in a truck close to the ship. The scrapings from the bottom were also removed at once this year. These constituted an intolerable nuisance and attracted numberless flies last year.

All the natives working, and on watch at night, in or near the dock were examined for Filaria Nocturna with the result that six out of twenty-six were found infected. In view of the supposed mosquito convection of this parasite this constitutes an additional reason for dealing with mosquito breeding places, more particularly as the mosquitoes captured on board or bred out appeared to be C. Fatigans in which it has been shown to develop. No anopheles were found this year.

Other possible sources of Infection.—These are to be found in the Mutwal prison a few yards from the dock and the thickly populated district on the other side of the Engineer's bungalow. It is probable that there is more risk during the North-east monsoon, as the wind then blows towards the dock from these, and the mosquito breeding places on this side are not accessible. During the stay of the "Hyacinth" there was a constant S. W. wind and very little rain.

It is suggested that these notes and the plan be kept for the information of the Medical Officer of any ship docking subsequently, and added to as any fresh breeding places are discovered, or any other information is acquired of interest from a sanitary point of view.



PLAN OF DOCK AT COLOMBO.

THE NECESSITY FOR THE ADOPTION OF

IMPROVED MEASURES FOR THE PREVENTION OF THE SPREAD OF INFECTIOUS DISEASE ON BOARD SHIP.

By H. F. BAWA, F.R.C.S.E.

Port Surgeon, Colombo, Ceylon.

Although quarantine measures for the prevention of the introduction of infectious disease from ship to shore have occupied the thoughts and energies of statesmen and sanitarians in all parts of the world for many centuries, the practical outcome of which are the enforced detention on board, or segregation ashore, of all contacts, or suspected contacts of infectious disease, the almost equally important question of the prevention of the spread of disease on board ship, has received comparatively little attention by modern practical sanitarians. As far as I am aware, there are no established rules or regulations, nor any facilities for accommodation, equipment or appliance for the effective isolation of infectious disease at sea.

It is obvious that limitations of space render the isolation of the sick a difficult problem at sea. I would urge upon the attention of Marine hygienists the necessity for considering its solution.

Isolation of a case of Plague, Cholera or Small-pox, even when it can be effected, in an ordinary ship's cabin, is manifestly undesirable. The alternative is isolation on deck. The problem is, how can this be done?

Without special provision or special equipment, no isolation on deck, worthy of the term, can be effected.

I would urge upon your attention that, while the developments of improvements in modern ship-building advances in great strides in all directions, while ample provision is made by the Shipping Act for life saving in the event of disaster at sea, while food, lighting, medical aid and the comfort of passengers and crew are attended to and as far as possible all requirements met, isolation of infectious disease is unprovided for, at any rate in the vast majority of vessels.

The prime essential of isolation being admitted, I would beg to submit, to this Congress, consideration of the following measures :—

A. The introduction of Government regulations, to be enforced by Boards of Trade, or incorporated in the Shipping Act, or provided for by special ordinance, insisting on the equipment with approved accommodation for isolation, specification of which should be laid down and subject to periodical Government inspection, such as is insisted on in the case of provision supply, life belts and boats, under the Shipping Act.

Such accommodation should consist of a permanent isolation cabin situated as remote as possible from the quarters occupied by the passengers, officers and crew, or of a portable and collapsible cabin of approved pattern to be laid down by regulation. I beg to suggest that a stout canvas cabin, supported on an iron or wooden frame work and capable of being bolted, tied, buckled or rivetted to the deck, would be the best measure.

With regard to the very important question of site for such cabin or cabins, the poop, the stern and the boat deck abaft the funnel, appear to me as the most suitable situations for isolation on vessels in tropical waters.

As Port Health Officer of Colombo, a large and important port in daily communication with infected ports on the neighbouring continent, where grave infectious disease is so largely and so continuously prevalent, I have had frequent occasion to observe and to deplore the utter inadequacy, or the total absence of any provision or facility for isolation of the sick at sea, and Gentlemen, I take the opportunity of urging upon you, now assembled in Congress, some of you representing important ports in the East, to consider whether an opinion or resolution on this matter, conveyed to the proper authorities, would not go far towards ensuring the adoption of compulsory measures for the isolation of infective, or possibly infective cases on board ship. And this I urge in the interest not only of the ship's company and passengers, but also in the interest of the public health of ports of call.

The measures suggested need not be expensive, nor the required accommodation difficult to devise or construct, but unless such measures are made compulsory and of universal application in vessels plying in the East, and unless subjected to Governmental control and inspection, it would, I venture to say, be useless to hope for any amelioration of the present unsatisfactory state of things.

I have to thank you, Gentlemen, for the patience and attention you have accorded me.

DISCUSSION.

Fleet Surgeon Clayton, in his remarks on this paper, said he wished to ask Dr. Bawa whether in merchant vessels it would be possible to carry out isolation in boom-boats. It appeared to him that in a boom-boat they had something quite as suitable as a portable cabin. It would of course, he admitted, be a different matter in a cold climate in the case of a patient severely ill, but in the tropics he held that the boom-boat was quite as suitable as an isolation cabin on deck.

Dr. Blackmore felt that there could be no doubt that attention to isolation accommodation for infectious diseases on boardship was wanting on most ships. He agreed with the last speaker that the boom-boat was a good medium for isolation in tropical seas, and believed that it was generally resorted to on steamers. He thought that on all pilgrim steamers a temporary isolation hospital should be constructed and that its provision should be insisted upon. To enforce this there would have to be an international agreement, but this could no doubt be arrived at as there was no doubt of the great need for this protection on boardship.

Captain Jones (*U. S. A.*) stated that with regard to ventilation the degree of overcrowding in the U. S. Transports appeared to be greater than in their Men-of-War. He agreed with the necessity for improved ventilation, but the difficulty was how to carry it out, not so much in smooth waters and tropical climates but when many men had to sleep on deck in stormy northern seas when the hatches and ventilators had to be battened down. A supply fan connected with the hollow iron masts seemed to be the only solution and was he believed being fitted. As to water the remarks made emphasized the necessity of a supply of distilled water for drinking, and the observations on the polluting properties of pipes the need for separate systems for shore water. He always regarded tonsillitis as infective and regarded it as an index of overcrowding on a ship.

Dr. Bawa, in referring to the remarks of Fleet Surgeon Clayton, said that the isolation of patients in boom-boats was sound so long as it applied to invalid able-bodied seamen. It would not apply to ladies and children. He knew of cases of infectious diseases on crowded ships with every cabin filled among women and children and he asked if it were possible to put them in boom-boats? He knew it was often resorted to in the case of children on crowded transports. He was of opinion that provision should be made on decks of all pilgrim boats and steamers for isolation cabins. In passenger steamers these should be on deck, in tramps in the forecastle. He knew the case of a German tramp in which an infectious disease occurred and it was eight weeks before he had done with that steamer. He thought there was absolute necessity for international co-operation in this matter. There should, he argued, be well concerted measures for isolation under Government control.

SOME FEATURES IN THE

SANITATION OF ARMY TRANSPORTS OF THE UNITED STATES

WITH REFERENCE TO DEFECTS NOTED AND IMPROVEMENTS NEEDED.

BY CAPTAIN HAROLD W. JONES,

Medical Corps, U. S. Army.

At the outbreak of the Spanish American war the United States Army had no Transport Service; in the ten years that have elapsed since the war the maintenance of the Transport Service as an integral part of the Army has been a problem at all times fraught with difficulty and even at the present time it rests upon no very firm basis. Altogether the United States maintains a fleet of sixteen vessels, seven of these being on the Pacific, five on the Atlantic, and four in the Philippine Islands. The Pacific boats make monthly sailings from San Francisco to Manila, while the vessels on the Atlantic coast make regular schedules when the transportation of troops demands this. The Philippine Islands transports also run regularly. The largest of these boats is some 7,000 tons, the total tonnage of the sixteen vessels being something over 40,000 tons. None of these vessels of the Transport Service was built originally for the transportation of troops; all were altered at great expense and while all are seaworthy perhaps, the newest, with one unimportant exception, was launched sixteen years ago, while the oldest is over 34 years old. Due to the policy, at present in force, of keeping our regiments but two years in the Philippines, the troops are practically in constant circulation, as it were across the Pacific; we maintain approximately 10,000 soldiers in the Islands and between July 1st, 1907 and June 30th, 1908, there were transported about 10,400 of our forces to Manila, while during the same period about 9,300 troops were carried to the United States. While the Army realizes the defects in its Transport Service, thus far no legislation has been secured for the construction of new and adequately designed vessels to take the place of our antiquated ones; indeed the American Congress has at intervals sought to do away with the service entirely, with the intention of moving troops to our foreign possessions by means of commercial liners. It must have occurred to all of us who have interested ourselves in the subject that our Transport Service is growing in importance; the continuance of our occupation of the Philippines, the recent necessity for moving over 5,000 troops to Cuba on short notice and the possibility that our intervention may be called for elsewhere, makes the problem of safely and successfully moving bodies of troops by sea an ever present one. That we have got along with what we have with some degree of success is perhaps creditable, but it by no means indicates that our system is altogether a success.

During the past 14 months the writer, in the capacity of Transport Medical Officer, has crossed the Pacific eight times covering a total distance of over 60,000 miles. In this paper he has made no attempt to cover the field of ship sanitation; some of the main features of sanitation as applied to troop ships are considered, and the principal defects as he has seen them are emphasized with suggestions for improvements.

For the sake of brevity the sanitation of the transport is considered under two heads; the sanitation of the vessel in general and the prevention, management and control of disease, especially epidemic disease. Under the head of the general sanitation of the vessel four things seem of the first importance, (1) The cleanliness of the ship; (2) The food supply and preparation; (3) The ventilation; (4) The water supply. Concerning the general cleanliness of our own Transports there is I think little to be said. Our ships are certainly as clean as they can be made under the present type of construction, indeed the troops *en route* have little else to do but clean ship. The main-

tenance of cleanliness presents ordinarily no difficulties, it is merely a matter of work, supplemented by thorough inspections on the part of those in authority.

With regard to the food supply there is also but little to be said. No one can deny that our troops on board are well fed and it has been in my experience a rare thing for a complaint to be heard in regard to it.

The proper and adequate ventilation of troop-ships has always been a hard problem, especially difficult is it under conditions demanding the transportation of a large number of troops upon a vessel of limited size. During my service of over a year I could never feel justified in saying that the ventilation was good or even adequate. The transport contained five compartments for the accommodation of troops, the largest of these containing approximately 25,000 cubic feet of air space while the smallest contained about 7,600 cubic feet. In the former there could be quartered 264 men while in the latter there were accommodations for 105. The amount of air space each man could have is readily found by division and in the five compartments referred to, was found to vary from 80 to a little less than 100 cubic feet. According to good authority ideal ventilation exists where each individual receives 3,000 feet of fresh air per hour or 1,000 cubic feet if the latter be changed every 20 minutes, but is usually agreed that such a condition is not to be obtained where there are large gatherings and where economy of space is to be considered as is the case here, so that if each individual can have 300 cubic feet and this be changed 6 or 7 times per hour good and sufficient ventilation has been obtained. With smaller amounts per individual there would be no difference theoretically if the frequency of the change of air went on in inverse ratio, but unfortunately 6 or 7 changes per hour is about all that can be obtained in practice and more than this results in draughts and discomfort.

The vessel on which I was stationed differs from the other ships in our service only in certain minor matters and may perhaps be taken as a type. She is fitted with four fans, two forward and two aft, which run constantly, forcing a current of air into the compartments occupied by troops. The air as it is finally delivered from the main pipe escaping through a large number of small openings situated at short distances apart. The fans make some 200 revolutions per minute and from calculations made by the chief engineer it was determined that when the fans were at full speed, and allowing a liberal amount for wastage, about 240,000 cubic feet of air per hour was delivered by these four fans into the five compartments used by troops. The total capacity of these five compartments was found to be approximately 78,000 cubic feet. By dividing the amount of air delivered by the capacity (240,000 by 78,000) we find that the air is changed about three times an hour. Is this enough? Let us take the actual figures and eliminate guesswork. Good and sufficient ventilation exists as I have said where the individual has 300 cubic feet with 6 to 7 changes of air per hour. In this case the individual receives one-third of this amount (100 cubic feet or less, as compared with 300) and the air is changed one-half as often (3 times as compared with 6). Thus the ventilation he receives on our transports is one-sixth of what is considered very good. I have personally satisfied myself by visiting the compartments at night that the air supply is none too good to say the least.

Regarding the water supply some interesting and at the same time difficult questions presented themselves. Our water is carried in water compartments situated within a false bottom along the keel. The supply has been from San Francisco, Honolulu, Hawaiian Islands, Marivales, P.I. and Nagasaki, Japan. The San Francisco and Honolulu water was the city supply, while that from Marivales came from a spring and was reputed absolutely safe; indeed the chances for contamination by human beings are small as the water is piped from high up in the mountains and there are no habitations near the source of supply. It was very seldom that Nagasaki water was used for drinking purposes, so it may be said that the three sources mentioned are all that need to be considered. The water was pumped from the compartments into tanks from which the whole supply of the ship was drawn as needed. This water was found upon examination to contain numerous amœbæ, diatoms, etc., and to show a bacterial count of over 2,000 per cubic centimetre, although the water compartments and tanks were steamed with regularity as well as mechanically cleaned. A change was then made so that all the water that was to be used for drinking was first passed through a condenser and there subjected to a heat of 220 deg. F. The water remained in this condenser but a few seconds, as it was in constant circulation on its way through the pipes to the cooling tanks. Previous to the change just mentioned, all the tanks and pipes had been steamed with live steam under pressure. It was found then that, although the water was for a few seconds raised to a temperature of 220 deg. F., this served only to "Pasteurize" the supply, so to speak. Counts made from the water taken practically boiling from the condenser showed less than 100 colonies per cubic centimetre; in other words about 95% of the bacteria were killed while the same water after passing direct through the system of tanks and pipes gave a count of over 2,000. At one time a progressive count was made after the tanks and delivery pipes had been steamed. The water from the condenser, as has been said, gave less than 100; 24 hours later the count from the delivery tank was 700; 48 hours later about 1,200 and a day or two after that 2,000. Naturally the absolute number of organisms makes no particular difference, and, while an examination of such a water by one unaccustomed to examining stored waters might lead to some alarm, I think it is only to be expected under the circumstances. Whether the amœbæ were pathogenic or not is open to argument, but no spontaneous cases of dysentery occurred on the ship. At all events the water could not be called safe while these were present whatever their source. After the change in the system with the boiling of the water the amœbæ disappeared. One thing was made very clear to me as a result of my observation of the water supply system on board, and that is that if a respectably low bacterial count

is to be obtained the storage tanks must be eliminated as far as possible and the number and length of pipes reduced to a minimum for it is there that the multiplication of organisms takes place. Whether a large number of saprophytes does harm to the individual is problematical, possibly they may account for some cases of indigestion and diarrhœa.

The Prevention of Epidemic Disease.

It must always be borne in mind that in the case of large bodies of men closely housed for a period of a month and without adequate opportunities for exercise, some of the most trivial and seemingly unimportant ailments may assume epidemic form and result in no little sickness. A consideration of the various diseases encountered on our transports with the measures for their prevention or control may be of interest.

Small-Pox.—This disease has for several years been practically eliminated from our Transport Service. All persons taking passage on our transports whether steerage or saloon passengers are required to be vaccinated unless they can produce evidence of recent successful vaccination. What constitutes the word "recent" is left to the judgment of the Medical Officer apparently, for I have seen no orders on the subject. In the light of some recent work on the length of time for which vaccination confers immunity I have personally set the time as one year.

Bubonic Plague.—During the recent epidemic of plague in San Francisco the Quarantine authorities there religiously fumigated the ship with sulphur at the close of each voyage. The number of rats on the ship must have been very small for I made a number of searches and it was only in the rarest instances that a dead rat was found. It is possible also that the sulphur was not effective. Rat guards were also kept on all hawsers while in port and the gangways were kept hoisted at night. No cases of plague have occurred on any of our transports recently.

Cholera.—During the recent epidemic of cholera in Manila all persons were personally examined by the Transport Medical Officer before being allowed to embark. In spite of this examination, in my own case during one voyage cholera came on board, the first case developing symptoms 12 hours out at sea. This man had fortunately been admitted to the ship's hospital immediately on coming aboard for a chronic otitis media, so that the portions of the ship occupied by troops did not become infected presumably. One other patient in the hospital who evidently became infected before the first patient could be isolated, came down with the disease. Isolation of these cases was of course instituted. The other measures enforced besides the thorough disinfection of the hospital with carbolic acid and the destruction of infected bedding, as prophylaxis, were simple and fortunately easily adapted to the military service. They consisted in the use of individual drinking cups each one of which was boiled after use, the boiling of all kitchen and table implements immediately after use and the requirement, under penalty of court martial for disobedience of orders, that every man scrub and disinfect his hands before eating. These orders were enforced by the commanding officer of troops on board. No other cases developed very fortunately. During our stay in quarantine at Nagasaki, Japan, I was afforded an opportunity to observe the thoroughness with which the Japanese quarantine officers did their work in that they personally examined every person on board during five days as well as in making a bacteriological examination of the stools of some 25 persons who had presumably in some degree, been exposed to cholera infection. Their disinfection of the ship however was not particularly thorough or consistent.

Tonsillitis and Diphtheria.—Tonsillitis has always been a very common disease in my experience, on transports and in that it may very easily become epidemic I have made it an invariable rule to admit to hospital all cases of sore throat. During some of my earlier trips this was not always done, but I am convinced, without having any actual figures to offer, that the morbidity rate has latterly become much less, for this disease. It is important of course, in the prophylaxis of this disease, to see that the compartments occupied by troops are kept dry, a few days of rough weather with leaky deadlights will certainly favour an epidemic. With regard to diphtheria I have seen no genuine case within a year although a bacteriological examination has been necessary on a number of occasions. All of our transports carry antitoxin and I have always kept on hand from 40,000 to 50,000 units.

Typhoid Fever.—Occasionally isolated cases of this disease are seen. The measures used for its control on shipboard are of course the same as those used elsewhere and do not merit further attention here.

The Exanthemata.—Measles is the *bête noire* of the Transport Medical Officer in the case of commands coming from the States. Here we have to deal with young recruits mostly enlisted but a month or two. While it is true that this disease is not in the list of those quarantinable, at the same time when it assumes epidemic form among large bodies of troops it creates no little havoc. Measles is practically never seen in the Philippines unless of recent importation and it must be very rare indeed in homegoing commands. In the case of troops outward bound it often happens that many of these have come directly from recruiting stations where there have been perhaps a few cases. Due to the rather long incubation stage of the disease troops might be exposed to it, journey across the American continent, embark upon the vessel, and finally show their first symptoms some days out at sea. For that reason I believe that the greatest care should be exercised, on the part of our medical officers at recruiting stations, in preventing men who have been exposed to measles from being sent on board until the time of incubation has been exceeded. An examination of troops by the Transport Medical Officer before they are allowed to embark is often times the means of excluding for the time being a few individuals who may have developed physical signs so as to allow of a diagnosis being made, but it is of course often impossible to detect cases early in the disease.

Once an epidemic has gotten under way it becomes an exceedingly difficult matter to check it. During one such epidemic among 1,200 persons on board, the writer

personally examined all the troops daily ; the temperature of every one to whom the slightest suspicion could attach, was taken ; even the slightest cold or redness of the eyes or malaise became cause for the use of the thermometer. While this was very irksome and required much time and inconvenience, it was the means of detecting a number of cases two or even three days before the appearance of the eruption. During the epidemic in which some 35 cases developed the whole of the poop deck was used as an emergency hospital while the isolation ward of the hospital was used as a detention ward for the suspicious cases. Fortunately the pulmonary symptoms of measles in the tropics do not seem to be particularly severe and all made good recoveries. During this particular epidemic also, a large number of the enlisted force was detailed by the Commanding Officer of troops at my request and these men were divided into sanitary squads each under the charge of a non-commissioned officer of the Hospital Corps. By means of these sanitary squads all portions of the ship which had been occupied by the troops, in which any cases of measles had occurred, were gone over with soap and water, followed with 5 per cent. carbolic acid, the work being done with the most absolute thoroughness.

Parotitis.—While this disease is not as troublesome in our service as measles, most of our measles epidemics have been accompanied by cases of parotitis. I have always examined the parotids of men coming on board in connection with the examination for the exanthemata and in two instances which I recall have detected parotitis, fortunately before the affected individual had embarked.

Scarlet Fever.—There has been no case of this disease during my service.

Venereal Disease.—It has not been my custom except in cases which show complications to place patients with acute gonorrhœa in hospital, but the names of the men affected are given to the Non-Commissioned Officer in charge and they are required to use separate bowls and water closets. They are also cut off the pass list for shore leave at the various ports touched at. All cases of syphilis if discovered are placed in hospital not only to protect others but to ensure treatment being carried out.

Pulmonary Tuberculosis.—It is my belief that a far larger number of cases of this disease develop upon transports than is generally supposed. In the case of a Regiment of Infantry which was sent out to thePhilippine Islands in the early part of 1906 by way of Suez, the time consumed being almost double that ordinarily required, the morbidity rate for pulmonary tuberculosis during the ensuing year for that particular regiment became so high that an inquiry into the cause thereof was called for. When the conditions of inadequate ventilation, overcrowding and usually prolonged voyage are taken into consideration it is not unreasonable to suppose that the spread of tuberculosis was favoured. On this account, and because I have seen no inconsiderable number of cases which seemed certainly to have developed on the transport, I have been more and more inclined, as my experience has lengthened, not to send cases of cough away from the dispensary with a bottle of cough medicine but to admit them to hospital for observation, in other words I believe in using the hospital on board ship not alone as a place to treat the sick and injured but as an adjunct in addition to the sanitation of the vessel and the troops on board.

Vermin.—Cockroaches are the plague of the pantry ; pediculi of the troops. When I joined the transport to which I was attached there were roaches in abandance. The stewards and pantrymen said they could not be gotten rid of and pointed to the fact that all transports were supposed to enjoy the company of roaches. Filling up holes in woodwork, renewing old woodwork, and keeping food covered in tin boxes as far as possible seemed not to discourage the pests, but the daily use of a certain roach salt, pounds of which were used in a month, banished them. This salt was spread literally everywhere throughout the pantries and dining rooms at night and was swept up during the day and for several weeks the amount used was very large ; later the roach invasion was controlled by the use of very moderate quantities daily. Bed-bugs are occasionally troublesome but a record is kept of each room in which they appear ; at the first complaint from anyone an army of stewards descend upon the room, and wood work, mattresses and bedding are painted with a compound which, although somewhat ill smelling, is effective. Pediculosis has been very troublesome and it seems almost impossible to completely banish it from the ship. As a routing measure all water closets are gone over two or three times a week with a strong solution of carbolic acid, and the attention of the men is drawn to the necessity of a minute personal examination where any suspicion exists, but in spite of everything cases are continually occurring, the conditions for the spread of the infection being of the best.

Position of the Transport Medical Officer.—It has always seemed to the writer that the sanitary service of our transports is insufficiently organized and perhaps insufficiently understood. Each Medical Officer as he assumes his duties must learn by experience and that experience comes at the expense of the service. The detail as Medical Officer of a transport is not generally regarded as a desirable one, and the position is one which by many persons is not taken seriously. In our service where large bodies of troops as regiments or battalions are transported oversea, it is usual to detail one or more Medical Officers for duty with the troops, but existing regulations make it clear that the Transport Surgeon, as he is designated (I much prefer Medical Officer), is responsible for the proper and thorough sanitation of the vessel. His reasoning must be consistent and the recommendations which he makes must be logical, sensible and easily understood if he is to have the support of those in authority. But as I have said before he learns something concerning ship sanitation, after six months or more, if he interests himself. If by that time he has not developed an interest along this line he probably never will.

In conclusion, I think that certain defects, which must exist in most troopships, have been suggested. Now-a-days with nations vying with one another in building costly battleships, and when the expense of naval programmes has become so great, it is perhaps hardly to be expected that they will wish to spend money on building

transports and, as I have said earlier in this paper, the United States has had to do the work of transporting troops with made-over ships. Without wishing to indulge in criticism of my own or any other nation before this gathering, let me suggest what I believe is to be desired in the matter of adequate and sanitary transport service for any power which is to-day concerned in the tansportation of troops for long distances by sea.

1*st.*—Large ships, ships capable of carrying from 3,000 to 4,000 men.

2*nd.*—Modern vessels, above all, those which can be kept clean and sanitary.

3*rd.*—Fast ships, capable of making from sixteen to twenty knots. In the case of the United States, this would cut down the time necessary for the voyage from San Francisco to Manila from thirty days to about eighteen.

4*th.*—Above all, let us insist on the necessity of an adequate air supply. This is, I believe, the most important point of all. We are careful to see that our soldier has enough air in barracks, but when he goes to sea we promptly smother him. Each man should have from 200 to 250 feet of air space and the air should be changed about four times per hour.

This shoud be regarded, I think, as the minimum and is something like three times what he receives at present on our transports. The subject of water-supply should also receive the most careful attention and a system should exist in which all water could be boiled and run practically direct from the source of sterilisation into small water coolers scalded out daily, without passing through a system of pipes and tanks as is the case with our present system. In other words just enough should be sterilised daily for necessary drinking purposes, and storage tanks should be done away with.

5*th.*—Lastly, I think, that the subject of transport sanitation should receive sufficient attention in schools for medical officers and prospective medical officers. It is my belief that this course should be included in that devoted to the subject of sanitation.

In closing, let me disclaim the intention of presenting anything original in offering this imperfect and somewhat hasty summary. I have to confess my own brief experience in ship sanitation, all experience which, although short, I have come to regard as of no small value. It is my belief that the importance of proper construction and adequacy of sea transport service is at present not thoroughly appreciated, at least by all nations.

DISCUSSION.

Fleet Surgeon Clayton, in remarking on Lieut. Jones' statement about ventilation and the degree of overcrowding on U. S. transports, said it appeared to him that overcrowding was greater in British men-of-war. He agreed on the necessity for improved ventilation, but the difficulty was how to do it. It was necessary to take measures for air supply not so much in smooth waters but in home waters when nine times out of ten the hatches had to be battered down. A supply fan connected with the hollow masts seemed the only solution and was, he believed, being fitted. With regard to water the remarks made emphasised the necessity of the supply of distilled water for drinking, and the observations on the polluting properties of pipes, the need for separate systems for shore water. He had always looked upon tonsillitis as infective and regarded it as an index of overcrowding on a ship. Tubercle was rarely contracted on a ship ; it was usually latent in the system.

Captain Jones stated that in connection with overcrowding he found the mistake the American authorities made on their transports was to put men into each compartment till they carried the full complement of 100. There were five compartments, but if only two hundred troops were on board instead of spreading them they were placed in two compartments and overcrowded. He had declared that unless there was a change in the system the men were bound to suffer.

THE EXISTING REGULATIONS FOR THE PREVENTION OF SEA-BORNE PLAGUE AND THEIR MODIFICATIONS.

WITH NOTES AS TO THE SHORE AND BOARDSHIP ENVIRONMENT OF MARINERS.

By B. S. SHROFF, L.M. & S.,

Medical Inspector of Seamen; Resident Medical Officer, British India Steam Navigation Co., Ld.; Honorary Medical Officer, Royal Alfred Sailors' Home.

The measures, concerted principally by the high authorities of the civilized world, to keep out the introduction of plague in their respective dominions as crystallized by their representatives at the Venice Sanitary Convention of the 19th March 1897, were based upon such information and knowledge of the disease as was then available. The Governments of Bengal, Burma, Bombay and Madras, drew up rules regulating inland and foreign human traffic by land and water, based on the suggestions made by the Convention. These suggestions reflected the following views ;—

That plague spread in a locality or was conveyed to neighbouring and distant places through the agency of persons suffering from the affection and through those who had come in contact with them, and who carried the infection broadcast on their persons, clothes and belongings. The actual mode of transmission of the disease in epidemic form was not then known. Strict quarantine

regulations were enacted and enforced by the Government of India all over the country, on all routes of traffic, on railways and waterways, causing very great inconvenience and hardship to the people of India. Almost all the inland measures have been discontinued in India since the meeting of the Venice Convention, which need not be detailed here. Inspection, disinfection, and detention of passengers were done away with on railways and on vessels sailing to and from all inland ports in India as soon as the Government of India saw the ineffectiveness of these measures. The inspections of ships and passengers going to coasting ports in Bombay Presidency were discontinued on the 19th January 1898, and the inspections of ships and passengers leaving Bombay for all Indian ports have been discontinued from 1st December 1908 to the great relief of owners of ships as well as passengers.

The discontinuance of inspection of ships, crews and passengers, and of disinfection of luggage, has not in any way contributed to increasing the risks of the spread of the disease to ports touched by the steamers leaving Bombay.

The Government of India have been induced to sanction the removal of inspection of ships sailing from and to Indian ports from the correct knowledge of the causes of the occurrence and spread of plague. This is a distinct advance on the information that was available to the scientific world at the time of the first Convention. The same knowledge ought to induce sanitarians all over the world to adopt regulations for ships and passengers sailing from India for foreign ports.

The Conference had laid down the incubation period of plague at ten days, although random proposals were made to fix at fifteen days ; in either case the time limit is not supported by scientific data. They also consider the numerous articles of merchandise, which were susceptible to carry the unknown infection of plague. The rat-flea, the only cause of introduction and spread of plague, was not known at the time. All Indian legislations and rules regulating measures for infection and disinfection of ships have been based on Chapter Second of the general Convention rules for the prevention, introduction and spread of plague.

It is now definitely stated by the Indian Plague Commission in their reports that—

1. Plague is neither infectious nor contagious, excepting pneumonic plague, which is a rare occurrence—(2·5 per cent. of all cases).
2. The course of the disease, on an average, generally lasts for five days only.
3. *Mus decumanus* catches it first in any locality and the *mus rattus* ten days later.
4. The infection in rats takes six weeks to travel 300 feet.
5. The epidemic lasts three months on an average.
6. The interval between an epizootic and an epidemic is fourteen days.
7. The rat epizootic precedes and is alone accountable for the human epidemic.
8. The aerial and bacillary infection through soil is excluded as playing any part in conveying the infection from animal to animal in nature.
9. In nature, the infection of rats by feeding rarely or never takes place, and the rats never become infected by eating the carcasses of their comrades.
10. The transmission of infection by food plays no part in the spread of plague in nature, either from rat to rat or rat to man.
11. The experiments made by the Commission lead then to the following conclusions :—
    (*a*) Fleas and fleas alone are the transmitting agents of infection, and they will not attack man unless forced to do so.
    (*b*) The incubation period of plague generally extends to three days.
    (*c*) The illness continues for five and-a-half days.
    (*d*) Fleas do not attack man in the presence of their natural host—the rat.
    (*e*) Starved fleas do not survive longer than a week.
    (*f*) A plague case is of no danger *per se* to those with whom it comes in contact.
    (*g*) The plague bacillus has no existence outside the human body.
    (*h*) Guinea-pigs kept in contact with bedding recently soiled by excreta of acute plague cases do not contract plague.
    (*i*) " It is necessary here to draw the attention to the bearings of these facts on the prophylaxis of the disease. Their teaching, with reference to such measures as disinfection, segregation of plague cases, etc., is too obvious to require comment."

In the light of these definite and authoritative opinions of the Indian Plague Commission, is it necessary to inquire whether the rules now in force regarding inspection of vessels at all Indian ports, particularly at Bombay, sailing to foreign ports and of their crews and passengers and disinfection of luggage of 3rd class passengers and Asiatic crews should not be abrogated or modified in conformity therewith ? The necessity for this becomes self-evident when it is fully realised what occurs upon a ship entering the port.

A ship on arrival is boarded by a number of people, who have to deal with her in numerous ways. A number of labourers board her day after day. Their persons and clothing are far more dirty, are more likely to harbour fleas and liable to drop them continuously on the ship to be availed of by their natural host—the rat, from which no ship is practically free. This state of affairs lasts till within a few hours of the departure of the vessel. Many cargo-boats come alongside a vessel and their Asiatic crews also visit it. The lighters generally carry some rats and notwithstanding certain regulations observed at this port for preventing their transference from ship to lighters and *vice versa*, their migration is not preventable. And similarly, migration of shore rats to the vessel is equally difficult of prevention owing to insurmountable conditions of contact taking place between wharfs and steamers in the docks. Firemen and deck-hands, European and Asiatic, visit the native town freely, and at times sleep out over-

The Existing Regulations for the Prevention of Sea-Borne Plague and Their Modifications.

Fig. 1.

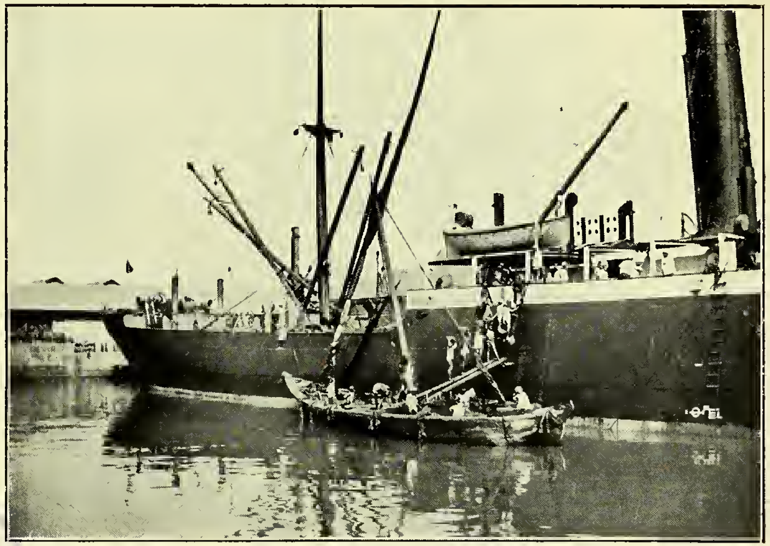


Fig. 2.

Fig. 3.

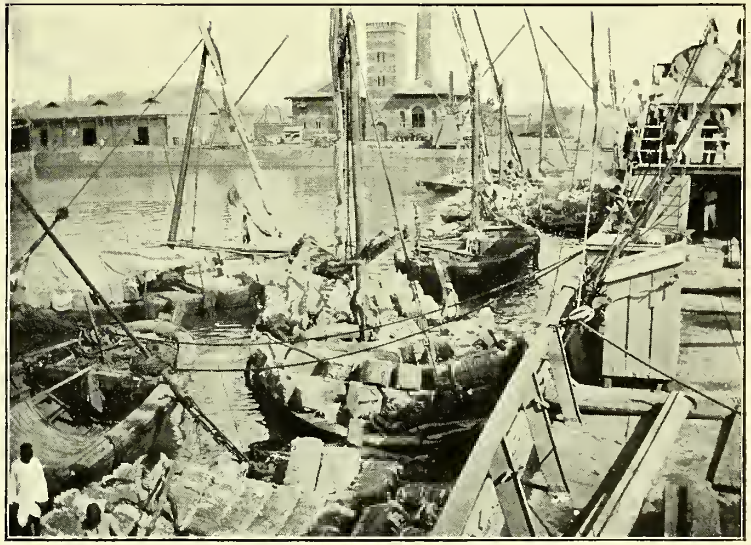


Fig. 4.

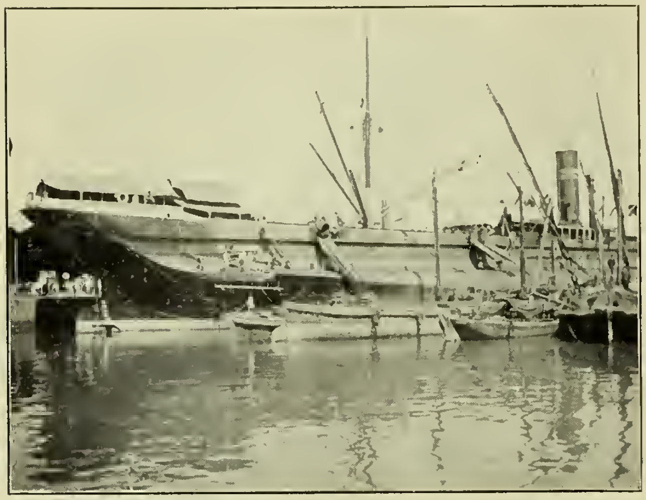


Fig. 5.

Fig. 7.

Fig. 6.

Fig. 8.

Fig. 9.

night, and are thus apt to carry fleas on their person and clothes to their respective ships. Thousands of tons of merchandise in bags are often brought to a ship from Bombay godowns infested with rats, and the bags cannot be free from fleas on their outer side. These conditions have been prevalent during severe epidemics of plague in Bombay, and yet they have not contributed to the spread of plague at outports. They are more likely to enable actual plague rats to migrate with their attendant fleas, which are the only means of transmission of the disease, and whose migration to the ships continuously takes place in face of all precautionary measures. It is possible there are some conditions on steamers which are inimical to the survival of fleas or to their causing spread of the disease which are not yet investigated. Were it otherwise, we should have heard of severe epidemics breaking out on board or at outports. The Government of India, after accepting the conclusions of the Plague Commission, have abrogated their quarantine rules for ships sailing from one Indian port to another. They would now do well to move the Home Government, suggesting to them to impress the high authorities of the civilised world, who were represented at the Venice Convention of 1897, firstly, that the medical inspection at Indian ports of European and Indian passengers and crews, and particularly of the first and second class European and Indian passengers, is not at all necessary as a measure for the prevention of the spread of plague on board of ships and at outports; secondly, that though the disinfection of the luggage of Asiatic crews and third class passengers, during the recrudescence of plague at any Indian port, might be contributing, though in a very small measure, to prevent the spread of plague on board of ships and at outports, it is not at all necessary, when the recrudescence declines, and keeps to a vanishing point during eight months of the year, as it often happens at Bombay and other Indian ports.

The Shore and Boardship Environments of Sailors—Europeans and Asiatics.

The environments of European Sailors on board of vessels are on the whole rather satisfactory.

Bathing Places.—A large number of canal steamers have no covered spaces set apart for bathing of crews, under the ranks of Officers and Engineers, who have either to take their baths on open decks or in the fore-castle close to their sleeping accommodation. Both the places are inconvenient. One leads to diseases consequent on exposure to draught and cold, and the use of the other tends to make the crews' quarters untidy, dirty and uncomfortable. The latter conditions are more marked in firemen's quarters, as they need constant cleaning of their persons several times a day. Owing to the want of a proper bath-room, they are often compelled to turn in without their bath, after their watches are over.

Cook-rooms.—In a large number of British ships cook-rooms are unsuitable for work in the tropics. Generally they are situated in the centre of the ships on the main iron decks, having no awnings on the side-decks. When the cooks after work become overcome with heat, as they often do, they have no place to cool themselves or avoid the heat of the galley, where, in addition, the moving space is limited, and where they are surrounded by metal fittings all round with metal floors, tops and bulk-heads. If the iron-decks by the side of the cook-rooms had awnings over them, the cooks and their assistants would be able to come up to relieve themselves from the heat of the galleys, which produces several heat affections in the tropics.

Food.—The diet table laid down for European seamen is very liberal. The issue of a pound and a half of fresh beef, however, is unsuitable in tropical ports, particularly in summer months, and leads to several troubles of the chylo-poetic system. If fish, vegetables and mutton were to be substituted, they would be found more wholesome.

Sick-rooms.—Almost all cargo-ships have no room set apart for the accommodation of any member of the crew when he becomes ill and requires a quiet and more comfortable place than a fore-castle berth. The accommodation provided in the fore-castle is barely sufficient for the ordinary wants of a seaman in health, and is often encroached upon by the storage of materials not required for the use of crews. The absence of separate accommodation tends to prolong ailments of sea-men who, at times, lay up from the commencement to the end of a voyage. The dietetic discipline in such cases is not exacted by the master of a ship or his medical adviser, and the patients often get from their comrades foodstuffs which are positively injurious to them on account of their sickness.

Cooling-rooms for Firemen.—Firemen are very subject to disease from the strenuous and continuous nature of their work close to the fires. One principal factor, contributing to their ailments, is exposure to draught at lower temperature on the deck immediately after leaving their places of work. If the ship-owners could be persuaded to provide covered places on decks, where they would rest for a while without being exposed to draught, a considerable amount of sickness among firemen would be obviated.

Fore-castle.—In cases of ships intended for traffic only, the space of 12 superficial square feet and 72 cubic feet allowed to each seaman is not sufficient for his personal comfort and maintenance of health owing to high temperature and the close state of the atmosphere in the tropics. The ventilation, provided through circular ports, is insufficient for the same reasons. They ought to be replaced or supplemented by oblong windows, which would be proof against rain and sea-spray in bad weather.

Head-covers.—European seamen suffer a great deal in the tropics, as they work in the sun without proper coverings on their heads as sola-hats. The majority of them wear ordinary skull-caps. If the owners of the ships could see their way to provide cheap sola-hats for their men, they would be doing not only an humane act, but would secure better work and greater efficiency from men working in comfort without laying up from the effects of heat exposure.

Mosquitoes in Bombay Docks.—These abound all the year round, and breed in still greater abundance in the hot months, and bite the exposed limbs of seamen on steamers, who do not sleep under curtains. They often cause inflammatory eruptions and even blisters. The

mosquitoes are of two kinds, malarial and non-malarial. The latter are more numerous, and breed in all the godowns in the docks. The former breed on the dock-walls close to the water line. If sulphur dioxide gas fumigation were effected in godowns by burning sulphur cakes, prepared according to the formula of Dr. B. P. Ghadialli, the Municipal Analyst, and the dock-walls close to the water line be scrubbed with a caustic alkaline solution, the nuisance could be materially abated. Malarial fevers are prevalent in the docks in hot months.

Excessive Building of Godowns in the Present Bombay Docks.

When the Prince's and Victoria Docks were built, sufficient open spaces between Godowns were not left for free circulation of air in the dock berths. All the available spaces left between Godowns have been or are being built over with temporary or permanent structures, blocking up the passages and preventing free access of air to the dock premises. These, with the addition of flats to some of the Godowns, render the berths—surrounded as they are with the existing stone-walls of Godowns, which get very much heated during the day—closer, warmer and more uncomfortable by preventing continuous dilution of air at the lower strata of atmosphere in the docks. This condition also tends to aggravate the mosquito nuisance. Attention of the Port Trust authorities may well be directed to these points to enable them to make better provision of free air passages between Godowns in their new docks which are being built at present.

Water-closets at Prince's and Victoria Docks.

As a rule the water-closets provided for European crews are situated at a great distance from some berths. They are found very inconvenient for sick persons on board, and particularly so when they suffer from diarrhœa which is a common complaint. If a closet is provided for the sick only close to every berth in the new dock, it would be a great boon to the shipping community.

The use of Aerated Waters.

The use of several non-descript aerated waters, that find ready sale amongst the shipping in Bombay, often cause gastric and intestinal irritation. Their sale ought to be prevented, and proper brands of aerated waters only ought to be allowed to pass on to the shipping community by the authorities concerned. The Superintendent of the Seamen's Rest has realised the danger, and has been doing his best to dissuade seamen from using indifferent aerated waters.

Causes of Death.

From the returns of causes of deaths occurring on board-ships while on their way to Bombay, recorded at the Bombay Shipping Office, it is found that out of a total of 36 deaths in 1906 and 57 in 1907, 7 and 17 deaths occurred among Europeans from the following causes:—

1906.

Causes.	*Number.*
Accident ...	1
Bronchitis	1
Dysentery	1
Pneumonia	2
Suicide ...	2

1907.

Causes.	*Number.*	*Causes.*	*Number.*
Cholera ...	1	Hepatic Abscess...	1
Drowning	3	Phthisis ...	1
Enteric Fever ...	5	Pneumonia	1
Fever ...	1	Syncope ...	2
General Debility	1	Unknown*	1

Diseases generally found amongst European Seamen at Bombay are as hereunder :—

Diseases.	*Diseases.*	*Diseases.*
Bronchitis.	Gonorrhœa.	Piles.
Burns.	Gastritis.	Otorrhœa.
Chancres.	Heart Diseases.	Self-abuse.
Diarrhœa.	Heat Exhaustion.	Smoker's hearts.
Dysentery.	Heat Stroke (mild).	Sun-stroke.
Enteritis.	Inebriation.	Tuberculosis.
Eczema.	Malingering.	Wax; inspissated wax in the ear causing considerable deafness.
Ear Furuncles.	Pneumonia.	
Fever.	Phthisis.	

Effects on the Health of Indian Lascars and Firemen from service on Board of Steamers.

As a rule lascars have better physique than firemen. After completing a voyage, they return to Bombay with increase in their body-weight, and improvement in their general health. The same is not the case with the firemen. The latter often take frequent and longer holidays, after completing their voyage. They seldom work continuously as the lascars, who generally make a series of long voyages lasting from three to twelve months. There is greater mortality among firemen at sea than among lascars. Out of total deaths with causes reported to the Bombay Shipping Office in 1906, 11 were among firemen and 11 among sailors, and in 1907, 23 were among firemen and 11 among sailors. The causes of death among Asiatic crews, reported to the Bombay Shipping Office, were as follows :—

Causes.	1906.	1907.
Accident ...	2	
Beri-beri	3	1
Bronchitis	1	......
Broncho-pneumonia	......	4
Brain Fever	......	1
Crush by Coal	......	1
Doubtful Plague...	......	2
Epilepsy ...	....	1
Erysipelas	......	1
Fever	......	1
Found dead in a chain locker	1	.....
General Debility...	3	2
Heart Disease	2	4
Inflammation of Lungs	1	......
Do. of Brain ...	1	......
Jumping overboard	1	......
Missing ...	3	6
Malignant Fever	2	1
Phthisis ...	2	2
Pneumonia	1	3
Plague	......	2
Strangulated Hernia	1	......
Syphilis ...	......	2
Suicide	1	......
Small-pox...	1	......
Syncope ...	2	3
Tetanus ...	......	1
Typhoid ...	1	......
Total ...	29	39

* European doctor.

This number does not represent the total number of deaths taking place at sea or at ports abroad among those shipped at Bombay.

The total number of native seamen shipped during 1906 and 1907 were 38,601 and 36,687, respectively, as can be seen from the following table :—

Year.	Description of Native Seamen Shipped.							Native Seamen shipped under Foreign Flags.
	Parsees.	Hindu Lascars.	Mahomedan Lascars.	Engine room Crew.	Saloon Crew.	Chinese.	Manillas.	
1907-08	216	3,226	7,129	17,096	8,152	126	15	2,653
1906-07	189	3,296	6,536	16,396	7,959	136	39	2,136

In the same years 144 and 202 persons were reported to have died abroad, and had owed some money to their employers in Bombay. Correct statistics are not available at Bombay.

Beri-beri is not often seen among Indian seamen. I saw a number of cases on board the Japanese steamers from 1891 to 1896, when they did not carry surgeons. Removal of the patients from their berths and detention on the deck under awnings, stoppage of rice-diet and dry fish, and their substitution by a diet consisting of wheat flour, fresh vegetables, fresh limes and mutton with ferruginous and heart tonics, led to recovery in about a fortnight.

Missing, Suicide and Jumping overboard.

Eleven deaths are recorded out of 68 under this heading. Out of these, 9 were among firemen and trimmers, and two among deck-hands. All the cases, I think, should be included under one heading. These incidents are generally due to unsuitable and unfit men taking up such work either through inducements of better prospects in life, or through imperfect knowledge of the nature of the work exacted in these capacities.

Lung Diseases.

Thirteen deaths out of a total of 68 were due to diseases of the respiratory system equally amongst the lascars and firemen ; this shows that Indian lascars are subject to lung affections in northern latitudes, and if they are sent further north, between the latitudes 38 and 43 in the Northern Atlantic, where the temperature ranges lower than 28 to 26 F., the deck lascars particularly would not be able to stand the conditions of sea-service obtaining there. On several occasions deck lascars have been taken to places situated at 38 to 43 north, in the Northern Atlantic, on the distinct understanding that they would not do any work, except that of mooring and unmooring their ships. They remained in their berths all the time the ships were in the latitudes further north.

DISCUSSION.

Dr. Bawa, remarking on Dr. Shroff's contention, said that the author had failed to convince that the main factor in convection of plague from shore to ship was by fleas carried on the persons or in the clothes of the cargo and coal coolies working on steamers. It appeared to him that cargoes in which plague fleas and their excreta existed was also an important factor, while it would be practically impossible to disinfect such a cargo before shipment. The disinfection of coolies before admission to a vessel was simple enough and could be carried out without undue hardship or inconvenience to them.

Dr. Shroff, in summing up the discussion, said that it was impossible to disinfect a hundredth or a thousandth part of the workmen, lascars and others who went on board daily. If the disease had not been carried out of Bombay it was not because of the measures which had been adopted to prevent it. He held that the plague and quarantine measures which had been framed ten years ago by the Venice Convention required to be reconsidered and this Congress should, he maintained, put forth an authoritative opinion before the Government of India and should urge the authorities of Europe to reconsider the question in the light of the present knowledge of the disease. Plague was not present all the year round but was only prevalent for four months of the year. He moved his resolution : "That the Government of India would do well to move the Home Government suggesting to them to impress the high authorities of the civilised world who were represented at the Venice Convention of 1897 (1) that the medical inspection at Indian ports of European and Indian passengers and crews, particularly of first and second class European and Indian passengers, is not at all necessary as a precaution against the spread of plague on board of ships and at outports and (2) that though the disinfection of the luggage of Asiatic crews and third class passengers during the recrudescence of plague at any Indian port might be contributory, although in a small measure, to prevent the spread of plague on board of ships and at outports, it is not at all necessary when the recrudescence declines and keeps at a vanishing point during eight months of the year, as often happens at Bombay and other Indian ports."

This resolution was seconded by Dr. Dinshaw B. Master.

Dr. Jehanghir J. Cursetji was of opinion that the resolution was very broad and as such would not have the acceptance of European countries. The idea was to keep the doubt as long as possible as they dreaded any importation of the disease from over the seas. Any attempt of the kind proposed would only put their backs up. In his opinion even if the meeting was unanimous the resolution would carry no weight and he did not think the Government of India would be inclined to forward it to the Home Government.

Dr. Turner asked what would their position be if such a small gathering passed such a resolution as that proposed by Dr. Shroff ; would it carry any weight ; and incidentally he asked whether it was wise or profitable also to pass the resolutions of Dr. Pearse and Dr. Katrak on the standard of water-supply.

Subsequently it was announced by the Secretary that all three resolutions had, in deference to the general consensus of opinion as to the inadvisibilty of their being passed, been withdrawn.

SEWAGE DISPOSAL.

By W. H. MAXWELL, A.M.INST.C.E.,

Borough and Waterworks Engineer, Tunbridge Wells Corporation.

The great bulk of scientific thought during the past 20 years, as applied to the disposal of sewage, has been directed almost wholly to the development of bacterial methods of purification. Although the necessary presence of micro-organisms for bringing about putrefactive and fermentation changes in organic matter had long been recognised, it was not until the Massachusetts State Board of Health in 1887 started their well-known experimental work at the City of Lawrence, U. S. America, on the purification of sewage and water, that the foundations of modern bacterial processes were laid down.

Since that time a vast amount of practical experience in biological methods of treatment has accumulated, and, though there is doubtless very much yet to be learnt, the settled principles of the process are now beginning to take definite shape. This is especially the case in England where, probably owing to the comparative smallness of its natural water-courses receiving sewage effluents and the density of its population, the question persistently forces itself upon public attention. During the past decade the map of this country has become well spotted over with works for bacterial purification, in which is gradually being worked out the most advantageous conditions under which the methods of Nature can be most economically applied to the service of town-dwelling man.

On the Continent of Europe, progress has been much slower than in England, and the system has not as yet seriously taken root, but good work has been carried out at the "testing stations" at Hamburg and Berlin in Germany, whilst French engineers have visited England to gather information of recent experimental work. In the U. S. of America, the Cities of Columbus, Boston, and Baltimore, have taken an important lead in initiating well organised systems of preliminary experimental work upon the results of which have been based extensive schemes appropriate to their respective needs.

Experience shows there are many factors affecting the successful purification of sewage by bacteriological means in different countries, and, in this connection, the writer desires to emphasize the importance of preliminary experimental work in the immediate locality to be dealt with, preparatory to laying down any extensive or costly permanent works. In England, much original work of this description has been carried out at Birmingham, Leeds, Sheffield, Manchester, Huddersfield, Salford, Hanley, London, and many other towns, and by this means present day practice has gradually been largely built up.

As in the case of most Municipal works, a detailed study of local conditions and requirements should first be made and the conclusions so deduced may then be advantageously utilized in the evolution of an appropriate scheme. Some leading features which necessarily modify the nature and design of works in different countries are—(1) the extremes of temperature under which the purification process is to be carried on, (2) the standard, or quality, of effluent demanded according to the nature of the water-way into which it is to be discharged, (3) the strength or degree of concentration of the sewage to be treated and the nature of its chemical composition and bacteriological contents, (4) the proximity of the works proposed to inhabited dwellings and the possibilities of nuisance arising therefrom, (5) and the quality and quantity of land available for the reception of the sewage effluent.

In considering modern methods of sewage disposal it is important to remember that the underlying principles involved in treatment by what is now understood as the "*bacterial process*" are analogous to those which bring about its *purification on land*, and the practical application of recent advances in bacteriological knowledge has given a new and increasing interest to scientific purification by this latter, and formerly much misunderstood, method. Failures in land treatment have arisen mostly through a disregard of the biological principles involved and lack of attention to the capacity of the land as compared with the quantity of sewage placed thereon. It is now a matter of history, in England, that an undue regard for the monetary aspect of sewage farming in many instances has led to the concentration of excessive quantities of sewage upon limited areas of land in order that profit-earning crops may be the more extensively grown. It is, of course, to be understood that suitable and legitimate cropping is an aid to purification and especially to the recovery or cleansing of land which has become "sewage sick" through overwork.

Though the principle of *land treatment* is perfectly efficient and sound, the sewageable area must, of course, be increased in proportion to the increase in population served by the farm in the same way that any other works require to be extended and adjusted from time to time to meet the increasing amount of work demanded of them. But, owing to the large and ever-increasing area of land required, it becomes impossible to deal with the sewage of large populated centres by land treatment alone, hence the highly concentrated form of the biological method upon the modern "bacteria bed," occupying but a mere fraction of the ground space, becomes imperative in all such cases.

The present status of the sewage disposal problem in England has evolved through certain definite stages which may be briefly referred to in the following chronological order, 1st, the "septic tank," 2nd, the "contact" bed, 3rd, the percolating bed or trickling filter with which is associated numerous forms of sewage

"distributors," and, finally, various means of removal of fine suspended matter from percolating bed effluents.

The "*Septic Tank*," in its original form, has already proved itself to be an unnecessary evil, and the idea is now happily falling into disfavor, as the experience of the past decade has shewn that it is not necessary that sewage should be made putrid (as the name implies) preparatory to the second or oxidising stage of the process of purification. In fact, there is good evidence to shew that the proper performance of these subsequent stages of the process are positively hindered in the case of highly septicised tank effluents, and the writer's experience leads him to the opinion that it is much more satisfactory, in every respect, to carry through the different stages of purification as quickly as possible whilst the sewage is still in a fresh condition. The smell arising from the distribution of septic sewage upon bacteria beds and upon land has, in some cases, been the cause of much nuisance and complaint prejudicially affecting the whole scheme of treatment and the interests of the authorities responsible.

Experience has also dispelled the notion that the "septic tank" solves the sludge difficulty, and that, although there is of course a certain, but very variable, reduction of the solids contained in the sewage, their complete dissolution in the tank is too slow a process to cope with the larger quantities ordinarily brought down daily to the outfall works.

There is no doubt, however, that suitable preliminary tank treatment is an important necessity as a first stage in any process of purification, but it is not needful that this accommodation should be so large as to allow the sewage to reach an advanced septic condition before passing forward to the second stage, neither is it necessary to cover such tanks in an airtight manner so that highly offensive and dangerous gases may accumulate.

One important necessity for what may be described as a "*preliminary preparation tank*" is that the variations of strength and composition of sewage occurring throughout the day are equalized and a more uniform effluent is produced for subsequent treatment. Also, the grosser solids are held back and partially dissolved, and the tank effluent, though perhaps stronger in its impurity, is rendered much more amenable for distribution upon either bacteria-beds or land. The requisite capacity of a "preliminary preparation tank" will depend upon the time and length of travel to which the sewage is subjected before reaching the purification works. In cases of a travel of several miles a stay of about six or eight hours in the tank will usually be sufficient. Small towns or villages where the sewage quickly reaches the outfall in a very fresh condition require a proportionately larger tank accommodation than larger towns with a long outfall in which the sewage may have undergone a thorough mechanical disintegration with partial bacterial decomposition and hydrolysis. In the case of sewage containing large quantities of "trade wastes" special preliminary treatment is often necessary, sometimes with the use of chemical precipitants, according to the character of the sewage dealt with.

After the incoming sewage has received a rough screening and insoluble matters, such as grit and sand, have been deposited, the writer has used a "preliminary preparation tank" of about 6 hours' capacity of ordinary town sewage. At the inlet end the grosser solids are held back in a compartment containing iron baffle plates whilst further dissolution and subsidence of fine suspended material takes place in storage compartments behind submerged cross walls preparatory to an aerobic treatment in contact with well vitrified clinker, under which latter the partially clarified sewage enters by means of an aerating floor and passes upwards and over a sill to the adjoining compartment, or away to the tank effluent channel off which the supplies to the percolating beds are taken. The sludge or deposit from all the compartments of this design of tank is readily removed by opening the outlet valves provided for each separate chamber, such outlets being all connected up with a single sludge outlet drain, which discharges under the hydrostatic head or pressure afforded by the sewage in the full tank, thus reducing labour to a minimum.

The effluent from the tank is well prepared for passing through "distributors" upon aerobic trickling filters without causing trouble from clogging, or it may with advantage be satisfactorily dealt with direct upon land. Where sufficient area of suitable land is available the aerobic filter-bed may thus be dispensed with altogether, thereby greatly simplifying and economising the problem of disposal, especially in countries where subordinate skilled supervision is not readily available. Effluents which have been allowed to become highly septic should not as a rule be treated on land, as great nuisance from smell invariably arises therefrom.

Contact Beds.—Fewer contact beds are constructed now than formerly, their place having been largely taken by the more recent percolating bed or trickling filter. The contact system is capable of yielding a very good effluent under suitable conditions, but double stage treatment (*i.e.*, both "primary" and "secondary" beds) is essential for procuring a satisfactory standard of purification according to English requirements. A considerable amount of "fall" is thus consumed, the double set of beds are costly, and a good deal of supervision is needed unless worked by some reliable automatic apparatus which can be trusted without constant attention and overlooking; but in the writer's experience all such appliances usually require a good deal of intelligent supervision.

The principle of turning crude sewage on to contact beds was soon found to be impracticable owing to the slowness of the digestion of the organic matter and the consequent choking, or sludging up, of the beds. The idea, in a different form, is still on trial in beds filled in a hollow or honeycombed way with layers of slate or flat tiles.

All contact beds should be constructed with a hollow or aerating floor so as to facilitate the thorough aeration and oxidation of the bed when resting, and permit of complete and ready drainage of the bed. This is a

matter the writer has often seen omitted, even in new beds, and must militate against the efficient working of the installation.

Another difficulty encountered with contact beds is their loss of capacity. This arises from the disintegration of the material within the bed and the settling together of the same, the latter resulting from the alternate filling and emptying of the beds. Other contributing causes are impaired drainage growths of micro-organisms and the choking effect of insoluble matter entering the bed. With suitable and grade quality of material, and careful working, the capacity tends to become constant at from 25 per cent. to 30 per cent. of the actual volume of the tank forming the contact bed.

Percolating Filters possess many advantages over the contact bed and are now more generally favoured. After preliminary preparation of the sewage it should be brought into as intimate a contact with the oxygen of the atmosphere as possible, so that all organic impurities may become thoroughly oxidised. This can be more thoroughly done on the percolating bed or trickling filter where the continuous and uninterrupted aeration of the sewage may take place. In the contact system the principle of the action of the bed is reversed at each filling from aerobic to anaerobic, the latter condition being more pronounced where the bottom of the bed is constantly water-logged owing to the absence of a proper aerating floor. The percolating bed deals with a larger quantity of sewage per unit of area and is usually less costly to construct. The two main difficulties of the system, however, are to secure perfect distribution of the sewage uniformly over the surface of the bed and to rapidly remove the fine suspended matter occurring in the effluent without incurring any very material addition to the capital cost of the works or subsequent working expenses. The best means of distribution now in use are attained by the well-known "rotary distributor" of which there are several improved forms and by the "fixed spray" or jet-system. Where there is sufficient fall and conditions are favourable the latter method is simple, comparatively inexpensive, and requires but little skilled supervision. The writer has constructed works with this system of distribution working under a 5 ft. 6 in. head; the resulting effluent is of a very satisfactory character and the cost of attendance and supervision has proved very small indeed. It is necessary, however, that the sewage be subjected to a proper preliminary preparation, and that it should be passed through the distributors before advanced septic conditions prevail. This system is in use at Birmingham (England), and is to be employed on a large scale at Columbus and Baltimore, in the United States of America.

Removal of fine suspended matter in percolating bed effluents.—The effluent from a properly constructed percolating bed, though not so free, generally speaking, from fine suspended matter as is that from the contact bed, will, nevertheless, be found to analyse well and keep well without subsequent deterioration. The suspended matter of the percolating bed effluent remains behind in the contact bed, resulting in a gradual loss of capacity and choking of the latter. Its regular removal with the effluent must therefore be regarded as an advantageous feature of the percolating system, especially as it can be removed by simple sedimentation or filtration. For this purpose the writer employs tanks containing a series of baffle plates and submerged inlets and outlets which remove the greater part of the fine matter sufficient for all practical purposes of sewage purification. But for still greater clearness of effluent water he has also used shallow filters of the water-works type filled with fine screened furnace ashes instead of sand. These give excellent results, and there is practically no limit to the degree of purification obtainable, provided the additional expense for each subsequent stage of the process is thought justifiable in the circumstances to be dealt with.

Recently, the Cities of Columbus and Baltimore, U. S. America, after prolonged investigation and experiment, have adopted important schemes of sewage purification involving short periods of preparation, distribution by fixed sprays or jets upon percolation beds, and the removal from the effluent of fine suspended matter by means of subsidence basins and shallow filters; and this, in the writer's opinion, is briefly the simplest and most effective set of stages to which the art of sewage purification has yet advanced.

Initiative in Sewage Disposal.—Were it not for the commendable initiative taken by local authorities and boards of health in carrying on original research work on a practical scale in regard to disposal of sewage, but little real progress in this direction could be recorded to-day. Many of such public authorities have availed themselves of the trained assistance of leading experts in the solution of the sewage disposal problem. Their work has been upon entirely original lines; they have sought to solve for themselves questions with which they have long been faced with practical sternness; they have had no regard for rules and precedent, and expenses have been met out of revenue. The work has been undertaken with a serious earnestness, and advantage has been taken of the latest advances in allied branches of scientific research, with the result that much valuable experience has been gained in regard to the practical application of a new principle which, when rightly applied, promises to lead to the complete solution of the hitherto insoluble question of efficient sewage purification. Had some arbitrary statutory requirement prohibited the free performance of this initiative work, the loss to the community would have been incalculable, but our local authorities, whose duty it is to make provision for the reception and purification of the sewage from their respective districts, have, by their persistent practical work, been enabled to lead the way, whilst those whose duty it may be to frame rules must follow in the wake of experience so derived, and build up "general conclusions" from the cumulative results of the work thus accomplished.

SOME OBSERVATIONS ON THE EFFECTS OF THE DISCHARGE OF SEPTIC TANK SLUDGE INTO A TIDAL ESTUARY.

By GILBERT J. FOWLER, D.SC., F.I.C.

A number of observations have recently been made in connection with the discharge into tidal waters of sludge from a septic tank installation designed by the writer in conjunction with Mr. J. P. Wilkinson, M.I.C.E., for the Admiralty Training Station at Shotley, near Ipswich.

These observations were in part suggested by the Reports by Letts and Adeney on the pollution of estuaries and tidal waters which the author was privileged to read in proof form.

It was in the first place of interest to discover how far their suggested standards of dilution would apply to the conditions at Shotley, while in view of the work of Purvies and Coleman,* of Clark† and also of certain unpublished results of the author there appeared room for further investigation of the effects of sea-water and fresh-water respectively on the rate of change of suspended sewage matters.

Shotley is a land station for youths taken from the old training ships. It is situated opposite the town of Harwich on the south side of a small peninsula having the river Orwell on the north and the river Stour on the south. Shotley Point is at the junction of the mouths of the two rivers.

The position of the septic tank installation and the outfall can be seen from the accompanying sketch map, on which also the track of the sludge discharge is indicated.

The sewage installation was designed for a population of 2,000 and consists of septic tanks followed by percolating filters, the effluent from which flows continuously out over the foreshore. Arrangements were made in the design for taking away the sludge in tank carts from time to time, but it was found more convenient to discharge it into the sea at suitable states of the tide.

About 8,000 gallons of mixed sludge and water were let out at each discharge, the operation extending over about half an hour.

The sludge valve was opened immediately upon or shortly after high tide, and the track of the discharge sludge observed. In all cases it passed along with the tidal water to the junction of the Stour and Orwell estuaries, where it apparently became indefinitely disseminated.

On October 2nd, 1906, samples were taken from a boat about 200 yards below the outfall in the track of the sludge. The time of high tide was 11·45 a.m., the sludge was let out from 12·0 noon to 12·30 p.m. and the samples were collected at 12·20 p.m. The samples were taken about one foot below the surface, care being exercised to prevent any air being mixed with the sample during collection. Two small bottles were filled for immediate examination, and a half Winchester was taken for detailed analysis on returning to Manchester.

The dissolved oxygen was determined in the small bottles by the Winkler method, in the one case shortly after collection and in the other case six hours later.

On returning to Manchester a portion of the larger sample was carefully syphoned off and the dissolved oxygen determined. A portion of the remainder was re-aerated and incubated at 20° C. for twelve days, and another portion submitted to a routine analysis.

A similar procedure was followed with samples taken at 2·30 p.m., or about two hours later on the same day.

A sample of sea-water was also taken for comparative purposes at a point above the outfall.

The results are summarised in the following table :—

—	*Sample A.* 12-20. p.m. Oct. 2nd, 1906.		*Sample B.* 2-30 p.m. Oct. 2nd, 1906.	
	Parts per 100,000.	C.c. per Litre.	Parts per 100,000.	C.c. per Litre.
Dissolved Oxygen.				
Shortly after collection ..	0·649	4·54	0·847	5·93
6 hours „ „ ..	0·667	4·67	0·811	5·68
10 a.m., October 4th .	0·342	2·39	0·738	5·16
After re-aeration and incubation for 12 days at 26° C.	Nil & smell of H_2S.		0·342 (Sea-water incubated similarly =0·522).	2·39 3·65
General Analysis, etc., October 4th.	Numbers in parts per 100,000.		Numbers in parts per 100,000.	
Colour	Nil.		Nil.	
Transparency	Opalescent with grey sediment.		Opalescent with whitish sediment.	
Smell	Very faint sewage.		Sea-weed.	
Oxygen absorbed 4 hours‡	0·54		0·24	
Ammoniacal Nitrogen ..	0·002		0·003	
Albuminoid „ ..	0·092		0·027	
Nitrous „ ..	Trace, more than B.		Trace.	
Chlorine	1930 (Sea-water 1940).		1910	

Allowing for small manipulative and analytical errors the above results show clearly :—

1. That the sludge quickly becomes mixed with a large excess of sea-water.

2. That in the course of 6 hours, *i.e.*, by half tide, practically no absorption of dissolved oxygen takes place at such a dilution and consequently no nuisance can arise from the discharge of sludge under these conditions.

* "The Influence of Sea-Water on the Decomposition of Sewage," *Journal Royal Sanitary Institute*, 1906, p. 433.

† Report of Charles River Dam Committee, 1903. Boston, Wright and Potter Printing Company.

‡ At laboratory temperature.

3. That two hours after discharge very little sludge can be detected in the water 200 yards from the outfall.

A similar set of samples was taken on May 29th, 1907. In this case the sludge was discharged from 1-30 p.m. to about 1-45 p.m., high tide being at 12-55 p.m. The intention was to discharge the sludge immediately at high tide, but a strong wind retarded the ebb for some time. One sample was taken about a quarter-mile from the outfall about 2-15 p.m., the other an hour later and rather further out. As before small and large samples were taken, but in this case, after determining the dissolved oxygen in one small sample immediately on returning to the shore, the other was securely fastened and sent back to Manchester and the dissolved oxygen determined some two days later, the samples not being incubated, in fact being kept for some hours after arrival in the refrigerator. They were at any rate kept during transit, &c., about 36 hours, at the ordinary temperature.

The following results were obtained :—

—	*Sample A.* 2-15 p.m. May 29th, 1907.		*Sample B.* 3-15 p.m. May 29th, 1907.	
	Parts per 100,000.	C.c. per litre.	Parts per 100,000.	C.c. per litre.
Dissolved Oxygen.				
Shortly after collection ..	0·705	4·93	0·83	5·81
May 31st	0·53	3 71	0 78	5 46
General Analysis, &c., May 31st.	Numbers in parts per 100,000.		Number in parts per 100,000.	
Colour	Nil.		Nil.	
Transparency	Clear with dark brownish sediment.		Clear with light brown sediment.	
Smell	Nil.		Nil.	
Oxygen absorbed 4 hours *	0·34		0·105	
Ammoniacal Nitrogen ..	0·016		Nil.	
Albuminoid „ ..	0·053		0·02	
Chlorine	1870		1880	

This set of observations agrees with the first in showing that in a short space of time the sludge becomes disseminated to such an extent as only very slightly to affect the composition of the water. The conditions at Shotley, it will thus be seen, fall easily within the standards either for Class I. or Class II. on p. 95 of Letts and Adeney's report.†

It was thought of interest to make some attempt to follow the ultimate fate of the organic matter, some of which is presumably deposited over a considerable area of the sea bottom. At the same time comparative observations were made of the course of decomposition in sea-water and fresh-water respectively.

For this purpose samples of sludge were taken from the inlet and outlet manholes respectively of one of the septic tanks. These samples were passed through a ½ mm. sieve to remove grit, fibrous matter, etc., and 10 cc. of the resultant mud added to a litre of sea-water and tap water respectively. This solution was further diluted to half strength.

* At laboratory temperature.

† See Extract from Report, appended.

The following solutions were thus obtained, which were distinguished as S_1, S_2, etc.:—

$S_1 = 1$	per cent.	by vol.	inlet	sludge	and	tap-water.
$S_2 = 0{\cdot}5$	,,	,,	,,	,,	,,	,,
$S_5 = 1{\cdot}0$	,,	,,	,,	,,	sea-	,,
$S_6 = 0{\cdot}5$	,,	,,	,,	,,	,,	,,
$S_3 = 1{\cdot}0$	,,	,,	outlet	,,	tap-	,,
$S_4 = 0{\cdot}5$	,,	,,	,,	,,	,,	,,
$S_7 = 1{\cdot}0$	,,	,,	,,	,,	sea-	,,
$S_8 = 0{\cdot}5$	,,	,,	,,	,,	,,	,,

500 cc. each of these mixtures were placed in half Winchester bottles plugged with cotton wool. The bottles being each of litre capacity were half full of air, and in addition to the free circulation of air through the cotton wool plugs the aeration was increased by periodical shaking.

Before describing the changes taking place in these bottles the following analyses of the original sludges after sieving should be given :—

—	Inlet Sludge.	Outlet Sludge.
Percentage dry matter	9·3	9·0
Organic and volatile in dry matter	24·2	57·3
Mineral in dry matter	75·8	42·7
Ether Extract (per cent. on total)	5·6	7·0
Ether Extract (per cent. on organic and volatile).	23·1	12·2

Incidentally it may be mentioned that a good deal of grit, fibrous and fatty matter, etc., was left on the sieve in the case of the inlet sludge, while nearly all the outlet sludge passed through the sieve. The septic tank has thus the effect of breaking up the original solid organic matter in the sewage and, consequently, as the sludge is only discharged from the outlet end or near the middle of the tank, it is in a condition to be rapidly disseminated throughout the water without the appearance of unsightly floating solids, and without the likelihood of rapid settlement of heavy solids.

The analytical figures show clearly that grit is deposited at the inlet end of the tank and also that the percentage of fatty matter extractable by ether diminishes in the course of tank treatment.

Very little smell was apparent from the first, in the mixtures of *inlet sludge*, either with tap-water or sea-water.

The following analyses, made on December 19th, 1906, after 76 days, of the 0·5 per cent. mixtures show that although ammoniacal fermentation had taken place in both cases, nitrification had been inhibited in the case of the mixture with sea-water.

—	S_2 (0·5 Inlet sludge and tap-water.)	S_6 (0·5 per cent. Inlet sludge and sea-water.)
Ammoniacal Nitrogen ..	·025	·21
Albuminoid „ ..	·115	·13
Nitrous and Nitric Nitrogen.	·20	·02

In the case of the *outlet sludge* mixtures there was a greater proportion of organic matter and all the mixtures had an offensive smell to begin with. This disappeared in about a week in the case of both the tap-

water mixtures and also in the case of the 0·5 per cent. sea-water mixture. The 1 per cent. mixture with sea-water was, however, black and putrid at the end of a month.

S_4 and S_8 were analysed on December 19th, *i.e.*, after two months exposure with the following results :—

—	S_4. (0·5 per cent. Outlet sludge and tap-water.)	S_8. (0·5 per cent. Outlet sludge and sea-water.)
Ammoniacal Nitrogen ..	·016	·082
Albuminoid „ ..	·26	·26
Nitrous and Nitric Nitrogen	Trace.	Nil.

Here again the lesser proportion of free ammonia in the tap-water mixture is evidence that nitrification is inhibited by the sea-water.

The 1 per cent. samples show a curious sequence of changes. As before remarked, the sea-water mixture remained putrid long after the fresh-water mixture, and the results with the 0·5 per cent. mixture show that oxidation of the ammonia to nitrites and nitrates proceeds more rapidly in fresh water.

On prolonged keeping, however, it was noticed that a small amount of green growth took place in the fresh-water sample which was absent from the sea-water, and on determining the free ammonia in S_3 (tap-water) and S_7 (sea-water) on April 19th, 1907, or seven months from the beginning of the experiment, 0·60 of ammoniacal nitrogen was found to be present in S_3 and only 0·20 in S_7.

No nitrite or nitrate could be found in S_3 but abundant *nitrite* was present in S_7. It is possible, therefore, that the nitrates originally formed in S_3 had been consumed by the green growth, which afterwards had suffered decomposition, reproducing ammonia.

It is curious to note that the loss on ignition of the suspended solids after these were collected by centrifuge and washed by decantation was always greater in the case of the fresh-water mixtures.

This is shown in the following tables :—

Inlet Sample.	Description.	Percentage loss on ignition of dry matter.
S_1	1 per cent. + tap-water.	56·0
S_5	1 „ „ + sea-water.	48·3
S_2	0·5 „ „ + tap-water.	58·4
S_6	0·5 „ „ + sea-water.	53·0

Outlet Samples.	Description.	Percentage loss on ignition of dry matter.
S_3	1 per cent. + tap-water.	53·5
S_4	1 „ „ + sea-water.	42·7
S_7	0·5 „ „ + tap-water.	56·6
S_8	0·5 „ „ + sea-water.	53·0

It was noticeable also that the suspended solids in the fresh-water mixtures had a more flocculent appearance than the corresponding sediment in the sea-water mixtures.

It seems, therefore, as if sea-water inhibits to some extent the growth of algæ, etc., which develop by utilisation of the organic matter. There would thus appear to be actually less organic matter present after long exposure of mixtures of sludge and sea-water than after similar mixtures with tap-water are exposed. A comparison of losses on ignition after exposure with those of the original samples as given in an earlier table also shows that little or no actual loss of weight has occurred in either case. Too much stress should not, however, be laid on this point, as the quantities to be weighed were comparatively small.

No doubt under natural conditions some of the organic matter would be consumed by infusoria and other low forms of life and thus enter once more upon a cycle of change. The inorganic matters will, however, eventually deposit, carrying with them also some of the organic matters of a more resistant kind.

In order to discover whether any evidence of such a deposition was left upon the foreshore, a careful examination was made at low-tide on September 20th, 1907, extending from the effluent outlet about a quarter of a mile along the track of the sludge discharge, samples being taken at different points.

The foreshore consists mainly of thick grey mud, shallow patches of sand occurring at intervals. There was no evidence anywhere of any permanent deposit of sludge or sewage matter. Immediately below the surface of the clay there was a blackish sub-stratum. This was apparently due to organic matter normally present, as it was found in places quite outside the track of the sludge and began always just beyond the limit of depth to which the air could penetrate. Evidences were frequent of the presence of molluscs, etc., below the surface of the clay, and this was always blackest in their neighbourhood, no doubt because of sulphate reduction caused by their excretions. None of the samples had any very appreciable smell, even after incubation, and loss of ignition of a sample taken close to the outfall was only 5 per cent., while a sample taken much nearer the dry land and out of the track of the sludge gave a loss of 8 per cent., both samples being sieved through a ¼ mm. mesh.

Scattered ribbons of *ulva latissima* were frequently in evidence here and there on the foreshore. A workman who was present contended that the weed was washed down from Ipswich. At any rate there were certainly no banks of it in course of formation.

As a result of the foregoing investigations, therefore, it may be concluded, if sludge consisting of finely comminuted solids, such as accumulate at the exit end of a septic tank, is discharged at the top of the ebb-tide under the conditions obtaining at Shotley, that while a temporary discolouration and pollution of the water takes place in the track of the sludge, yet at no time is the aeration reduced appreciably between tides, and

finally the solids are so widely distributed that no visible effect is produced, although the actual transformation of the organic matter requires considerable time.

The researches have further shown clearly that, under the conditions of experiment described, nitrification does not proceed so quickly in sea-water as in fresh, and both under these conditions, and under those described by Adeney,* oxidation of nitrogen only reaches the stage of *nitrite* formation, in presence of sea-water. It has also been shown that the smell is much more persistent in mixtures of sludge and sea-water than in similar mixtures with fresh water, and therefore special care is necessary, before discharging unoxidised sewage matter into the sea, to be sure that the conditions are such that nuisance cannot arise. In the present case other means of sludge disposal had been provided for, if the sea discharge had been found impracticable. Even as it was the laboratory experiment demonstrated that the amount by volume of the sludge to be added to sea-water must be less than 0·5 per cent. if nuisance is not to arise. This was only possible if care was taken to let off at the top of the ebb. If too long time elapsed after the turn of the tide before discharge, the whole of the blackened water was not carried away and remained near the shore till the returning tide.

In view of the work of McKee undertaken at Letts's suggestion, and quoted by the latter in a recent paper†, it would appear most probable that the persistent odour of a mixture of sludge and sea-water is due largely, at any rate, to the production of sulphuretted hydrogen through the reduction of sulphates. In presence of nitrates it appears reasonable to assume that rapid oxidation of the sulphuretted hydrogen would occur. The effect of sea-water on nitrification is, therefore, seen to be an important factor in conditioning the production or otherwise of nuisance, and consequently it becomes necessary more exactly to determine the conditions under which nitrification is retarded or inhibited by sea-water.

Further work is also desirable on the mutual interaction of sulphides and nitrates under varying conditions and also on the sources of evil-smelling compounds in mixture of sewage and sea-water. It is likely that malodorous compounds other than sulphuretted hydrogen are also produced by the decomposition of complex nitrogenous substances which may require the presence of nitrates for their rapid oxidation. The well known effect of nitrates in preventing putrefaction on incubation would point to this conclusion.

Researches by the present writer and his assistants are in progress with the object of throwing further light on these points.

The laboratory work in connection with the investigation here recorded was carried out in the Public Health Department of the University of Manchester, when special provision has recently been made for the chemical and bacteriological study of sewage.

The thanks of the writer are due to the authorities of the Admiralty for the facilities afforded in making the observation at Shotley, and for permission to publish the results.

APPENDIX.

EXTRACT pp. 94-96 FROM REPORT OF Prof. LETTS AND Dr. W. E. ADENEY ON THE POLLUTION OF ESTUARIES AND TIDAL WATERS.

Royal Commission on Sewage Disposal, Appendix VI to Fifth Report, 1908, *Wyman & Sons, Limited, 109, Fetter Lane, E.C.*

The capacity of tidal waters to dispose of the sewage matters discharged into them must obviously be defined for a given state of tide; the distance from the outfall at which the test samples are to be collected must also be defined.

These two questions can only definitely be settled by careful investigation, both in the laboratory and on the open water, for typical localities. From our own experience we believe that the distance from the outfall might be fixed at about 200 yards; and that the state of tide selected should vary according to whether the sewage is, or is to be, discharged on the ebb tide only, or at all states of the tide or during any portion of the flood tide as well as the ebb. Under the former condition, the selected state of the tide might be that occurring at the fourth hour of the ebb, but under the latter condition, it would be safer, we think, to take it at low water.

In those cases in which an outfall does not exist, but a position for one has been selected, the diluting power of the tidal waters may be roughly gauged by discharging into them a strong solution of eosin or of other suitable colouring matter near the selected position, in calm weather, and collecting samples along the path taken by them. The degree of dilution of the colouring matters in these samples could be approximately estimated by comparing them with known dilutions of some of the solution originally employed.

Subject to the foregoing considerations, we may formulate standards for each of the three classes of tidal waters as follows:—

Standard for Class 1, which may include tidal waters, the currents of which are strong enough to transport all sewage matters, including suspended solids, from the neighbourhood of the outfall, and so widely to distribute them through large volumes of sea water as to render them practically innocuous before change of tide.

Tidal currents, which ebb with sufficient strength to carry all sewage matters discharged into them, both solid and liquid, and widely to distribute them in open

* Addendum to Section I. of Report, p. 435.

† "On Effluvium Nuisances, more especially such as occur in Tidal Localities." *Journal of the Royal Institute of Public Health*, February, 1908.

water before change of tide, will also, under most circumstances, be in sufficient bulk to dilute them to such an extent and quickly to render them practically innocuous. We have an example of this in the successful disposal of the sewage matters of Portsmouth. These are stored in tanks of 4½ million gallons capacity, and are thence discharged into the Langstone Channel during the second hour of the ebb tide, and are carried away by the tidal currents into the English Channel.

It does not seem necessary to formulate a standard for such favourably situated tidal waters.

There are localities, however, *e.g.*, Newport (Mon.), where crude sewage is discharged into narrow tidal ways at all states of the tide, and is, moreover, satisfactorily disposed of by the tidal scour. But, from our inspection of the River Usk at Newport in August 1904, we formed the opinion that it would not be safe largely to increase the volumes of sewage then being discharged into the river in the crude state. It seems to us, therefore, that a limit should be placed upon the quantity of crude sewage which may be discharged into tidal ways, more or less favourably situated for their adequate disposal.

The standard to meet these cases should be formulated in accordance with the above considerations, thus :—

> The aeration of a sample of mixed sewage and tidal water collected at low water (average tide) in calm dry weather at any point 200 yards from the outfall, or of a sample of the sewage when mixed with tidal water in the proportion of the ascertained diluting power of the latter at the given distance, when such mixture is kept out of contact with the air for 12½ hours at 18° C., shall not fall below 2·8 c.c. oxygen per litre.

Standards for Class 2, which may include tidal waters, the ebb currents of which can transport liquid sewage matters, and widely distribute them in open water.

Liquid sewage matters, when the solid matters have been previously separated from them, may be discharged into this class of tidal water either (*a*) on the ebb tide only, or (*b*) at all states of the tide or during some portion of the flood tide as well as of the ebb.

(*a*) *Discharge on the Ebb Tide only.*

The standard may be formulated thus—the aeration of a sample of mixed sewage and tidal water collected at the commencement of the fourth hour of the ebb of an average tide in calm dry weather at any point 200 yards from the outfall, or of a sample of the sewage when mixed with tidal water in proportion of the ascertained diluting power of the latter at any point, at the given distance, when either is kept out of contact with the air for 6¼ hours at 18°C., shall not be less than 3·1 c.c. oxygen per litre.

(*b*) *Discharge at all States of the Tide.*

The standard may be formulated similarly to the one above given for Class 1.

Standard for Class 3, which includes all other tidal waters not so favourably circumstanced.

Liquid sewage matters may also be discharged either (*a*) on the ebb tide only, or (*b*) at all states of the tide, or during some portion of the flood tide as well as of the ebb.

(*a*) *Discharge on the Ebb Tide only.*

The standard may be formulated thus—the aeration of a sample of mixed sewage and tidal water collected at the commencement of the fourth hour of the ebb of an average tide in calm dry weather at any point 200 yards from the outfall, or of a sample of the sewage when mixed with tidal water in proportion of the ascertained diluting power of the latter at the given distance, when either is kept out of contact with the air for 48 hours at 18°C., shall not be less than 0·85 c.c. oxygen per litre, and the subsequent rate of absorption shall not exceed 0·055 c.c. oxygen per litre, per hour.

(*b*) *Discharge at all States of the Tide.*

The standard should be formulated similarly to the preceding one, except that the test sample should be collected at low water of an average tide.

Standards required to meet Special Cases.

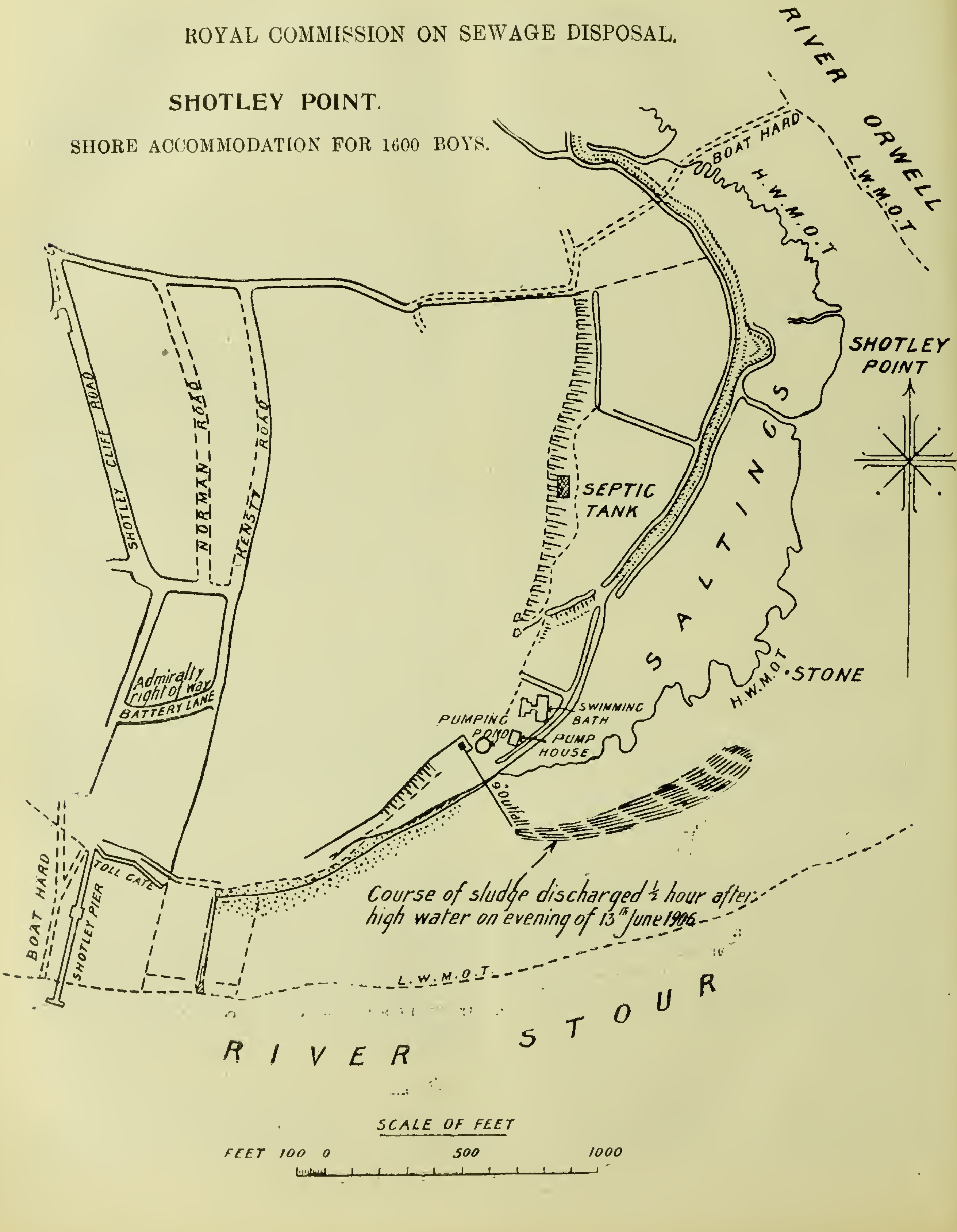
As already pointed out, the above standards would not form adequate protection against the growth of undesirable sea weeds, such as *ulva latissima,* which rapidly develope and spread in the presence of sewage matters, where the topographical conditions are also favourable. The conditions which conduce to the growth of these weeds have been made the subject of careful investigation by one of the authors (Letts), and it has been shown by him that it is the inorganic nitrogen constituents of sewage or of sewage effluents which encourages their growth. Hence, to avoid setting up favourable conditions, the sewage must be specially purified with the object of getting rid of its nitrogen compound as far as possible. The results of this investigation has been summarised in another Section of this Report, entitled "Indirect Nuisances caused by Green Sea-weeds."

The above standards could not also be regarded as a sufficient protection from discolouration of the waters of health resorts. Crude sewage or sewage which has only been screened and settled, even in very small proportions, exerts a very decided discolouring effect in the waters into which they are discharged. Hence, only good sewage effluents from filter beds or from land treatment should be allowed to be discharged in their neighbourhood.

ROYAL COMMISSION ON SEWAGE DISPOSAL.

SHOTLEY POINT.

SHORE ACCOMMODATION FOR 1600 BOYS.



THE TREATMENT OF SEWAGE UNDER TROPICAL CONDITIONS.

By GILBERT J. FOWLER, D.Sc., F.I.C. (Urmston near Manchester).

Introductory.

The subject on which the author was requested to contribute a report to this Section of the Congress is defined as "The Effect of the Mechanical, Chemical and Biological Purification of Sewage."

After consultation with the General Secretary, it has been considered that more interest and value would attach to a paper on the Treatment of Sewage under Tropical Conditions, in which the author has recently acquired special experience, than to a report on more general lines. Moreover, the results obtained in tropical countries are capable of throwing light upon the problems met with under ordinary European conditions.

The author has recently had occasion to spend some months in the East, initiating experiments, which have been continued for about a year under his direction, having for their object the determination of the conditions of successful treatment of the sewage of concentrated populations in tropical countries.

It will be useful, in the first place, briefly to describe the methods of sewage treatment and disposal at present in practice in the East, and to indicate their limitations.

Among scattered country populations, *e.g.*, native villages, where there is abundance of land in the vicinity, purely primitive methods are in force, and if exercised with ordinary rationality are probably the most satisfactory.

With greater concentration of population and in the absence of sewers it becomes necessary to take away excreta and slop-water and dispose of them in trenches, or pits. Provided the trenches are not made too deep and the soil is of a loose and porous character this method of treatment can be fairly satisfactorily carried out. Where the conditions are unfavourable, however, it may tend to become an expensive nuisance.

A third state of affairs presents itself where sewers are constructed but no provision is made for water-closets. Here the slop-water and urine, or "sullage" as it is termed, finds its way to the outfall and the excreta are either taken away for trenching or "dumped" at convenient points into the sewer. This system obtains in many cities of the East. Provided that the removal of the excreta from the house is prompt and efficient, such a method, in the author's opinion, is much more sanitary than water-closets often are found to be. Unless a water-closet is thoroughly efficient in design and operation, which can only be the case if there is an abundant and continuous water-supply, it may easily become a serious nuisance, even under European conditions, as the author can testify, and still more so therefore at a tropical temperature.

The sewers, whether containing sullage water only or combined sewage, may be led to a river or tidal outfall. The advisability of direct discharge without further treatment depends on a variety of circumstances, mainly on the dilution which can be effected at the point of discharge, and on the possible use of the river for water-supply. This question affords matter for a discussion in itself, and will be dealt with as Subject No. 6 of this Section.

It is no doubt better, where possible, that the sewage should be purified before discharge into a stream. Direct application to land without previous tank treatment is apt, unless conditions are very favourable, to lead to difficulty and nuisance.

After anaerobic treatment in tanks, however, the resulting effluent can be readily dealt with on land and has been found to have a favourable influence on crops. This method, therefore, has much to recommend it, and where suitable land is to be found, should be adopted, especially where rainfall is limited. Under such conditions the effluent may very likely all be absorbed by the crops, or disappear by evaporation, and so no pollution of water-courses is to be feared.

The problem becomes more difficult where no suitable land is available, where the population is concentrated and where there is risk of polluting water which may be used for domestic purposes. It was such a condition of things that the author was called upon to investigate. The sewage was received in tanks, connected either directly or by short lengths of sewer, with flushing latrines, and the main problem consisted, in the first place, in making the tank treatment as efficient as possible and afterwards in devising means for the satisfactory purification or disposal of the tank-effluent.

Special Conditions affecting Treatment.

In dealing with such a problem, it is necessary, in the first place, to carefully consider the various factors which are peculiar to the special circumstances. Perhaps the first factor in importance is temperature.

Temperature.—Thus, avoiding extreme cases, available records indicate that the maximum temperature in the tropics may be assumed to be 8° C. above the maximum temperature in Western Europe, while the minimum temperature will be about 16° C. higher in the tropics than in Europe.

When it is considered that the optimum temperature for the cellulose destroying organisms is above 37° C.[1] and that a high temperature is also favourable to the decomposition and final nitrification of nitrogenous organic matter, it will be seen that the temperature factor is a very important one. While the effect of temperature, if the proper conditions of treatment are maintained, will be to facilitate purification, it also increases the liability to failure and nuisance if these conditions are neglected.

Water-supply per head.—The water-supply per head as a rule is likely to be much less than under European

[1] Omeliansky, Centralbl. f. Bakt. 1902 (11), pp. 193 & seq.

conditions and may be as little as 3 gallons per head up to as much as 10 gallons. The present paper has reference mainly to sewage of about 5 gallons per head strength.

Diet and habits of people.—The diet and habits of native races in the East of course vary greatly from those prevailing in the West. A much larger proportion of the population subsist mainly on a vegetarian diet. This will consist chiefly of rice and lentils with a smaller proportion of flour and curry, and consequently the proportion of offensive nitrogenous matter present will be less than in European sewage. As a rule also a smaller proportion of urine will have to be dealt with than in ordinary town installations as the native will almost certainly make use of the roadside or field if occasion arises. Water is largely used instead of paper for cleansing purposes. Much less soap and grease will also find its way into the sewers, as a large proportion of personal ablutions and washing of clothes takes place in rivers or ponds. Even where wash-platforms or laundries are connected to the tank a less proportion of soap will probably be present than under similar conditions in Europe.

Typical Analyses of Native and European Sewage.

All these factors yield a sewage which, though strong when regarded simply from the point of view of dilution, is considerably less troublesome to deal with than a corresponding European sewage would be. The following analyses of average samples of vegetarian native sewage and European sewage of equal dilution (5 gallons per head) indicate the differences to be looked for:—

	Parts per 100000	
	Native.	European.
Oxygen absorbed 4 hours test	41,71	31,3
Nitrogen Ammoniacal	2,91	17,98
,, Albuminoid	6,19	5,17
,, Organic (Kjeldahl minus albuminoid)	10,77	15,62
Chlorine	9,3	26,2
Total solids	256,0	206,0
Sulphur	2,05	3,72

The greater proportion of ammoniacal nitrogen and of chlorine in the European sewage is manifestly due to the greater proportion of urine, while the higher figures for organic nitrogen and for sulphur indicate the greater liability to nuisance in the case of the European sewage.

Preliminary Anaerobic Treatment.

James' experiments.—Valuable work has been done in connection with the treatment of sewage under tropical conditions by Mr. C. C. James, [1] now Engineer-in-Chief to the sewerage of Cairo. The sewage he had to deal with was fairly dilute and the chief interest of the experiments lies in their demonstration of the results which can be obtained at a high temperature by tank treatment under anaerobic conditions.

The work which can be done by a "liquefying" or "septic" tank at tropical temperatures is phenomenal, and is an excellent instance of the differences in result which are brought about by differences in the conditions which obtain. A paper has recently been published by Dr. Dzierzgowski describing careful experiments made with domestic sewage from the Czar's Palace at Tsarskoe Selo near St. Petersburg, from which the conclusion is drawn that the liquefying action of the tank and also the amount of gas given off are negligible.[2]

On the other hand, James found (and his experience is quite borne out by the writer's own work) that the deposit in the tank needs only partially to be removed at the end of 3 years, and an effluent is obtained nearly free from visible solids during most of that time. At the same time large volumes of combustible gas are evolved which can be collected and utilised

Composition of tank gas.—This gas is termed by Mr. James "tank gas" and is undoubtedly mainly due to temperature difference. In St. Petersburg the temperature seldom rose above 17,2° C. while in James' experiments the average temperature of the sewage was from 25,5° C. to 32° C. There is little doubt that the gas consisting, as it does, largely of CH_4 and CO_2 is chiefly derived from the fermentation of cellulose, and Omeliansky's work[3] already referred to has shown that this is due to two organisms, one producing methane and CO_2 and the other hydrogen and CO_2, the optimum temparature for the hydrogen baccillus being higher than for the other. The proportion of methane and hydrogen will therefore vary with the temperature. The writer is at a loss to account for the rather large percentages of nitrogen recorded by James. In the course of his investigations he made numerous analyses of the gas evolved in the anaerobic decomposition of native sewage both in the laboratory and in the latrine itself.

The following represents the composition of James' "tank gas"[4] :—

CO_2	5—16	per cent.
CH_4	24—32	,,
H	12—20	,,
N	48—60	,,

Only a trace of oxygen and no CO was ever found in the gas.

On the other hand two analyses by the author of gas drawn from a latrine tank gave the following figures :—

CO_2	5,5— 4,7	per cent.
CH_4	46,5—47,0	,,
H	2,1— 3,1	,,
O	8,9— 9,3	,,
N	36,0—37,3	,,

It will be seen that the oxygen and nitrogen are in the proportion to form air; there is therefore no nitrogen present which can be put down as being evolved from the sewage. The conditions of sampling in this case made it difficult to avoid the presence of a certain amount of air in the sampling vessel and its connections. The only occasions in the course of many experiments in the laboratory when appreciable quantities of free nitrogen were present with no corresponding oxygen was when fairly fresh sewage matter was allowed to ferment and the first portion of the gases evolved analysed separately. In two such cases from 38 to 41 per cent. of nitrogen was obtained. The gas afterwards evolved contained only traces of

[1] James, "Drainage Problems of the East," Chaps. V—VI.

[2] Gesundheits-Ingenieur, pp. 261—277, 1907.

[3] loc. cit.

[4] "Drainage Problems of the East," p. 203.

nitrogen. Another experiment showed that if fresh sewage was allowed to ferment in presence of an effluent containing nitrates free nitrogen was also evolved. It may be concluded therefore that the greater proportion of gas evolved is due to cellulose fermentation. It would appear likely that the nitrogen of the "tank-gas" is originally dissolved in the incoming sewage and is driven out of solution by gases of fermentation.

It is stated by James that, with a sewage flow from 430 persons at 30 gallons per head per day and a rest in the tank of 8 hours, and with only two compartments of the tank covered in, a volume of gas varying according to temperature from 1,050 cubic feet to 1,550 cubic feet has been obtained. It is considered that it would be quite safe to calculate upon an average volume of 3 to 4 cubic feet of gas per head of population per day throughout the whole of the twelve months.

Before the gas can be used for power purposes the CO_2 must be removed by lime purifiers.

The gas thus purified is used to actuate a 1/2 HP gas engine, to light the compound and building and for cooking.

It is evident that if the nitrogen could be eliminated the calorific value of the gas would be greatly increased. In view of the author's results above referred to it would appear desirable to concentrate the solid matter in the sewage as far as possible in a compartment at the inlet end of the tank, and collect the gases from the main tank separately. In this way any nitrogen evolved in the early stages of decomposition, and any dissolved in the water, would be driven off in the inlet compartment, and the gas produced in the main tank would be proportionately enriched.

Rate of flow through tank.—In designing tanks for the anaerobic treatment of sewage the length of time during which it is necessary for the sewage to remain in the tank must be carefully determined. In James' experiments with a 30 gallon per head sewage 8 hours was found to be sufficient and European practice is tending to the same conclusions. With the more concentrated sewage with which the present writer had to deal a much longer time was customary and an important part of his investigation consisted in determining, if possible, the relation between the concentration of the sewage and the time of passage through the tank.

Laboratory experiments on tank capacity.—For this purpose a number of laboratory experiments were made and the results compared with those obtained in actual practice.

In the laboratory experiments large bottles were used, from 3,6 up to 9 litres capacity, and fresh sewage of known strength, from 10 to 5 gallons per head, passed through, under conditions imitating as far as possible those obtaining in practice.

"*Inoculation*" *of Tank.*—At the outset a singular result was obtained. It was found that if the contents of the bottle were "inoculated" at the beginning of the experiment with sludge from a latrine tank in good condition, the fermentation proceeded regularly from the first, and an effluent of normal character was produced. If however no sludge was added the effluent possessed an exceedingly offensive smell and was not so well purified on subsequent filtration. In course of time a more normal fermentation supervened, but a difference persisted between the two cases for a considerable time, and the sludge eventually obtained was more offensive in "non-inoculated" than in the "inoculated" sewage.

Results of comparative experiments.—The periods of time allowed in the comparative experiments on tank capacity for the sewage to pass through the bottles were 72 hours, 48 hours, 32 hours and 24 hours respectively.

The following results with 5 gallons sewage may be quoted to show the comparative results obtained.

	Parts per 100,000			
	72 hours.	48 hours.	32 hours.	24 hours.
Oxygen absorbed 4 hours.	8,39	9,07	10,26	10,80
Ammoniacal nitrogen ...	7,29	6,42	5,94	5,61
Albuminoid ,, ...	0,95	1,12	1,24	1,48

These results show a clear superiority in the case of the 72 hours period. The actual numbers obtained show that the effluent is much worse than that obtained in practice on the working scale. This was almost certainly due to the difficulty of retaining suspended matters in a bottle to the same extent as can be done in a tank.

Composition of latrine tank effluent.—A typical analysis from a latrine tank in good working order and of a capacity equal to a 3 days' flow is as follows, though many even better results might be quoted :—

Appearance	Turbid small quantity suspended matter.
Smell	Strong fœcal.
Total solids	51,00 parts per 100 000
Loss on ignition...	18,50 ,, ,, 100 000
Ammoniacal nitrogen	4,00 ,, ,, 100 000
Albuminoid ,, ...	0,24 ,, ,, 100 000
Chlorine	3,00 ,, ,, 100 000
Oxygen absorbed 4 hours test...	2,94 ,, ,, 100 000
3 minutes test (before incubation)	1,09 ,, ,, 100 000
(After incubation)	1,37 ,, ,, 100 000

It will be seen that the rise in the 3 minutes oxygen absorption test is much less than is generally found in the case of a septic tank effluent in Europe. In many cases in fact no rise at all took place. On mixing latrine tank effluents with tap-water in the proportion of 1 part effluent to 9 parts water and incubating, the oxygen very generally disappeared in 48 hours, but it was by no means always the case.

It would appear therefore that it is possible by purely anaerobic treatment at a temperature of 30° C. and upwards to so decompose a vegetarian sewage that the effluent contains only the residual products of proteolysis, and yet without production of nuisance. This would seem to be due to the smaller proportion of sulphur already referred to.

Residual solids in tank.—The residual solid matter left either in the latrine tank or the experimental bottles consisted, when the working conditions were satisfactory, mainly of finely divided husks of rice, &c., blackened by traces of sulphide of iron and having the appearance in bulk of tea-leaves. In the cases where the tank was overworked or the bottles had not been inoculated at the outset the sludge was of a more offensive character. The following are the percentages of carbon and nitrogen

obtained on analysis respectively of the residue from evaporation of vegetarian sewage and of the deposit in a latrine tank.

	Carbon.	Nitrogen.
Crude sewage	27,6	8,25
Tank deposit	25,71	2,84

It is evident that the greater part of the nitrogen goes into solution in the effluent while the carbon remains in the tank as cellulose which is gradually decomposed into methane, hydrogen and carbon dioxide in the manner already referred to.

PRINCIPLES OF CONSTRUCTION AND MANAGEMENT OF LATRINE-TANKS FOR ANAEROBIC TREATMENT.

Preliminary.—Although it must be confessed that the experiments and observations in the foregoing paragraphs are of a somewhat empirical character they appear to justify the belief that the length of stay of sewage in the tank is, roughly speaking, inversely proportional to the concentration. On general principles this is what is to be expected. The total solid matter to be deposited is the same per head whatever the dilution may be, and its rate of decomposition is largely independent of the rate of flow through the tank, while the hydrolysis of the substances in solution and emulsion, by bacterial or enzymic activity, will take place more rapidly in dilute solution than when the sewage is highly concentrated. This point requires however more careful study than it has hitherto been possible to give it, though preliminary experiments in the laboratory confirm the above conclusion.

The following recommendations are therefore based mainly on the results of observations of latrine tanks in use and on the experimental studies referred to in the last section.

Capacity of tanks.—The capacity of the tanks should be such that a sewage diluted with 5 gallons of water per head should occupy approximately 3 days in passing through the tank. For this purpose 2 cubic feet (12.5 gallons) per head of water holding space should be provided, in addition to a further allowance of 20 per cent. of this space for purposes of "heading up" as explained in the next paragraph.

General principles of construction of tanks.—The tanks should be constructed in such a way that the solid excreta, etc., are retained for the most part in a compartment at the inlet end of the tank and there broken down and gradually liquefied while the liquid portion of the sewage passes on slowly and without the formation of currents, and consequent dead spaces, to the outlet, depositing undissolved matter on its way.

As the delivery of sewage is not constant throughout the 24 hours provision should be made for partially ponding up the sewage in the tank during the hours of greatest use, and allowing it to run off during the remainder of the time, thus ensuring an equable flow through the tank and also an equable discharge on to the filter beds connected with the tank.

Provision should further be made for the periodical removal of the undissolved mineral and other matter accumulating in the tank in course of time.

DETAILS OF CONSTRUCTION OF TANKS.

Shape of tanks.—In order to secure the above conditions the tanks should be of rectangular shape, the length being at least 6 times the width. This proportion may usefully be increased, if otherwise convenient, good results having been obtained in England with tanks whose length was 14 times their width.

Depth of tanks.—The average minimum depth should be 6 feet, a fall of 1 foot being allowed in the direction of the outlet end. A further depth of about 15 inches should be allowed for heading up.

Inlet Chamber.—A compartment whose volume is equal to one-eighth the total volume of the tank should be formed at the inlet end by the construction of a mid-feather wall the lower two-thirds of which are pigeon-holed. As a result of this arrangement the solid excreta will form a floating mass on the surface of the inlet chamber, the liquid portion of the sewage passing in an equable manner through the pigeon holes into the body of the tank.

Sludge outlets.—The bottom of this inlet or grit chamber should be sharply dished to an outlet valve at the bottom so that the heavier grit and mineral matter may readily be removed from time to time and prevented from passing in too great quantity into the main tank.

A similar arrangement of outlet valves should be fixed at the outlet end of the tank to remove the residue left after bacterial action has taken place.

Effluent outlets.—Three outlet pipes for the discharge of the effluent should be provided equidistant from each other in the outlet wall of the tank. These pipes should dip down one-third of the minimum depth of liquid in the tank. Their combined discharging capacity under the head of water which will obtain at the time of maximum sewage delivery should not be more than can readily be dealt with by the filter beds attached to the tank. This arrangement will consequently obviate any over-working of the filters.

Manholes.—Inspection manholes should be placed in the inlet chambers, and at the inlet and outlet ends of the main tank.

Gas collection.—If for any reason it is considered desirable and economical to collect and burn the gases evolved from the tank, the main tank, excluding the inlet compartment, may be converted into a gas-holder by hermitically sealing with a balanced floating iron cover, well pitched to prevent leakage, from which the gas can be withdrawn under reduced pressure. In this way a minimum percentage of nitrogen will be obtained. Carbon dioxide and any unpleasantly smelling products can be removed by passing the gases through lime-purifiers. The residual gases will thus consist mainly of marsh gas and hydrogen and can be readily burnt and used for power or heating purposes.

Management of tanks.—On starting a new tank it should first be filled with clean water and if possible a quantity (say enough to cover the bottom of the tank to the depth of 1 inch) of liquid sludge introduced from a tank in active operation. The full number of users should not be admitted at once, but the load should be increased

gradually beginning say with one-third the calculated number and increasing to the full number at the end of 3 months. From time to time during this period analyses of the effluent should be made, especial attention being directed to the ratio of free and albuminoid ammonia. The character and amount of deposit should also be ascertained from time to time by examination with a dipping tube.

When the tank is in full operation, occasional analyses of the effluent will still be necessary, especial attention being given to the suspended matters present. If these are at all excessive, and if examination with the dipping tube shows that more than a foot of deposit is present at the outlet end of the tank, a portion of this should be withdrawn by the sludge valves.

In the same way the amount of grit in the inlet chamber should be ascertained from time to time and if necessary a certain proportion should be removed.

Disposal of sludge.—On no account should the sludge and deposit withdrawn from the sludge valves be discharged into a watercourse, but it should be trenched into the ground, or dried on small draining beds and burnt.

FILTRATION OF EFFLUENT FROM ANÆROBIC TREATMENT.

In order to obtain information as to the conditions of efficient purification of tank effluent on percolating filters, an experimental filter was set up in connection with a tank latrine.

As the impurities to be oxidised were mainly in solution it was judged advisable that a considerable proportion of the filter should be composed of material of small dimensions.

Details of construction of filter.—The material used was hard furnace clinker and the grading was as follows from the top downwards :—

6″	to pass	¼″	and be rejected by	$\frac{1}{16}$″
18″	„ „	1″	„ „ „ „	¼″
2′	„ „	2″	„ „ „ „	1″
1′	„ „	2″	„ „ „ „	3″
1′	large pieces.			

The total depth, it will be seen, was 6 feet, the upper surface area was 4 square yards.

The material was placed on a concrete bottom, and the filtered effluent was collected in a channel surrounding the filter and discharging ultimately into the drain carrying the main flow from the latrine.

The whole material was held in place by an enclosure of wire netting.

Distribution of tank effluent.—About one quarter of the flow from the latrine was led on to the centre of the filter by means of a galvanised iron channel and distributed over the surface by smaller radiating channels. A low banking of fine material was arranged to prevent any of the liquid flowing over the sides.

Measurement of flow.—Several measurements of the flow were made by allowing it to run into a 3-gallon bucket and noting the time of filling.

As a result of these it was concluded that the average rate of flow through the filter was certainly 200 gallons per superficial yard or 100 gallons per cubic yard. This gave nearly 4 gallons per cubic foot, or 1 cubic foot of filtering medium per person.

Sundry observations.—When the filter was in full operation it was noted that only about half the surface of the filter was actually covered with liquid. In this form of filter it is undesirable to completely cover the surface with liquid and it was evident from the examination of the filtered effluent that the conditions for purification were satisfactory.

There was very little sign of clogging on the surface. The temperature of the unwetted surface was 43°C. the temperature of the incoming tank-effluent 32°C.

Chemical results of purification.—The average composition of the tank-effluent and filtrate respectively taking the mean of 4 complete comparative analyses was as follows :—

	Parts per 100000 Tank	Filter
Oxygen Absorption—		
4 Hours Test (including nitrites) ...	2,59	1,16
3 Minutes Test (including nitrites) ...	0,90	0,47
Nitrogen—		
Ammoniacal	5,01	0,43
Albuminoid	0,195	0,055
Nitrous and Nitric	—	2,73
Chlorine	5,1	5,0
Percentage Purification—	—	
4 Hours' Test	55,2	—
3 Minutes' Test	47,7	—
Ammoniacal nitrogen	91,4	—
Albuminoid nitrogen	71,7	—

The samples with very few exceptions were clear and bright in appearance, being often indistinguishable from tap-water even when in Winchester quart bottles.

An examination of the details of the individual analyses showed that, although in many cases the almost complete nitrification of the ammonia was accomplished, yet after deducting the oxygen absorption due to nitrites, a small amount of matter capable of slow oxidation by acid permanganate in 4 hours was frequently still left in.

Colloidal matter in effluents.—The following results of a comparative dialysis experiment show at any rate that colloidal matter could be practically eliminated :—

X = liquid outside dialyser. Y = liquid inside dialyser.

	Tank X	Tank Y	Filter X	Filter Y
Oxygen absorbed 4 hours	1,61	0,62	0,99	1,03
Nitrogen—				
Ammoniacal	2,24	2,56	0,04	0,03
Albuminoid	0,196	0,048	0,08	0,06
Chlorine	3,2	3,0	3,2	3,0

Ratio of colloids to crystalloids :

$$= \frac{X - Y}{2\,Y} = \frac{\text{colloids}}{\text{crystalloids}}$$

Calculated on 4 hours oxygen test :

$$\text{Tank} = \frac{1{,}61 - 62}{1{,}24} = \frac{0{,}99}{1{,}24}$$

$$\text{Filter} = \frac{0\,99 - 1{,}03}{2{,}06} = \frac{0{,}04}{2{,}06}$$

Calculated on albuminoid ammonia :

$$\text{Tank} = \frac{0{,}196 - 0{,}048}{0{,}096} = \frac{0{,}158}{0{,}096}$$

$$\text{Filter} = \frac{0{,}08 - 0{,}06}{0{,}12} = \frac{0{,}02}{0{,}12}$$

The same conclusion was confirmed by other dialysis experiments and by precipitation of the colloids with basic ferric acetate.

It is evident therefore that a filter of this type if not overworked is capable, with but little attention, of giving excellent purification, in the case of an effluent from a tank latrine in satisfactory working order.

Percolating filters and contact beds.—Owing to the difficulty of watching contact bed operations in the field it was found necessary for comparative purposes to institute laboratory experiments in connection with the experiments on anaerobic treatment already described.

For this purpose small percolating filters were constructed of glass tubes about 2 inches internal diameter and upwards of 3 feet long. They were filled to a depth of 3 feet with filtering medium broken to about ¼ inch pieces.

The contact beds consisted of 2 gallon buckets provided with a tap at the bottom and filled with material of a character similar to that used in the percolating filters. The contact beds were filled once per day, 4 hours contact being given.

The average results are given in the table on p. 429. The full analyses unfortunately were not made for the laboratory percolating filter but the presence of nitrites and nitrates was qualitatively recognised and the presumption, having regard to the field experiments, is that they were probably present in greater amount than in the effluent from the contact beds.

PRELIMINARY AEROBIC TREATMENT.

Apart from the possibilities of nuisance where the process is improperly conducted, the anaerobic tank treatment presents certain inherent difficulties in special cases.

It may often happen that there are considerable variations in the flow to be dealt with at different periods of the year, *e. g.*, in the case of schools or institutions where the greater number of the users may be absent for some weeks during the year on holiday. In such a case if the tank is constructed sufficiently large to deal with the maximum flow, it becomes almost stagnant at the minimum and nuisance may easily result. Where the fluctuation is not too irregular this difficulty may be partly got over by constructing the tank in sections and from time to time flushing out the sections not in use, with clean water.

Such a method however hardly meets a case such as occurred in connection with a pilgrim shelter at a railway junction on the line to a great pilgrim resort. Here the normal user of about 1,000 people might be increased in one day to 6,000 by an influx of pilgrims.

Moreover in the cases of temporary concentrations of population such as military camps, fairs, &c., it may not be practicable to put up expensive permanent structures such as anaerobic tanks.

For such cases as these direct treatment on aerobic filters appears to be the most satisfactory method.

Experiments by James have shown that it is perfectly possible to obtain excellent results by the direct treatment of sewage in a filter of the Ducat type. He recommends and the present writer is in agreement with him that the top layer of such a filter should be of coarse material, so that the excreta, &c., may be sooner disposed of and also that the sewage discharged into the filter may not "head up."

James's experiments were originally with sewage of 40 gallons per head strength, though recently it has been reduced to 10 gallons strength.

In general it is likely to happen that even this dilution is not easily obtained.

The author therefore instituted experiments with 5 gallons per head sewage to determine how far purely aerobic methods were capable of affecting purification in such a case.

Description of experimental plant.—The object of the installation being to study the composition and behaviour of native sewage under strictly defined conditions, a small two-seated latrine was built in the vicinity of the experimental plant, from which it was possible to obtain the liquid and solid excreta of a specified number of users.

The experimental plant consisted essentially of the following parts, *viz* :—

A. Receiving tank.
B. Primary contact beds.
C. Secondary beds to be used either as contact beds or percolating filters.
D. Sand filters.

The receiving tank A consisted of a rectangular box of galvanised iron. The dimensions of this tank were 2 feet by 2 feet 6 inches deep, the water content being 8 cubic feet, or 50 gallons : equivalent to an assumed daily sewage contribution or 5 gallons per head from 10 persons.

This tank was intended to impound the daily sewage discharge from 10 persons as described, and to be discharged, when full, by hand through a conical vertical plug in the bottom, into an inlet or feet channel, from which it could be admitted at will by means of conical wooden plugs to each of the primary contact beds in succession.

The primary contact beds or tanks were five in number, each 3 feet 6 inches by 3 feet 6 inches by 2 feet 9 inches deep (inside dimensions).

The filling material occupied the whole interior space of each tank to a depth of 2 feet 3 inches.

These primary beds were originally intended to operate on the principle of Mr. Dibdin's recently devised aerobic slate beds, and if slate was unprocurable it was proposed to use thin flat tiles separated by wooden laths as distance pieces. It was not found possible to obtain either slates, or this form of tiles. It was necessary therefore to make use of ordinary bricks broken in half, set carefully at approximately equal intervals of about an inch or less from each other and separated horizontally by wooden "slats" about half an inch in thickness.

Each tank was provided with an iron stop cock by which the contents could be discharged into the corresponding secondary beds, and from which at intervals, if necessary, the accumulated deposit could be sluiced out.

The secondary beds or tanks were constructed of the same size as the primary tanks, and of galvanised iron. The filtering material varied somewhat in the different beds, but was generally speaking graded in varying proportions from 1/8″ material on the surface to material of upwards of 2″ diameter at the bottom.

The final sand filter tanks were constructed in concrete, water works sand being placed into a depth of about 1 foot

over about 3 inches of broken brick. The sand filters discharged into an adjacent small pond. The water for the installation was pumped by hand from a large pond near by.

Routine of operations.—The routine of operations was as follows :—

At 7 a.m. every morning the excreta from 5 persons were placed in the receiving tank which was filled up with water (the dilution per head being thus 5 gallons) and its contents thoroughly mixed and discharged on to one of the primary filters. One filter was filled every day in turn. After 2 hours contact the contents of the primary filter were allowed to slowly run into the secondary filter, 6 hours being occupied in the operation.

It was originally intended that the secondary filters should be worked as continuous percolating beds, but, in order to get the whole of the material "matured" and to prevent the formation of channels in the material, the exit stop cocks were kept closed and they were allowed to fill up and act as contact filters. As it was found that the greater part of the purification was effected by the secondary beds when thus worked this method of operation was continued. The effluent discharged from them at 3 p.m. was however allowed to flow continuously through the sand filters about two hours being taken for this operation.

A difficulty which arose from this mode of operation during hot dry weather was that the primary beds especially tended to dry up during the intervals between each dose. It was found necessary therefore to keep the installation moist, under these conditions, by pumping up water on to the beds every day from the adjacent pond. No nuisance was developed throughout the course of the experiments.

The general results eventually obtained are given in the following table where they are compared with the laboratory experiments on filtration after preliminary anaerobic treatment. The results from the sand filters were somewhat erratic, owing to the difficulty of preventing the formation of channels in the filtering medium, but an appreciable increase in purification was effected by their use.

Average experimental Results.

Description of sample.	4 hours oxygen test.	Chlorine.	Nitrogen. Ammoniacal.	Nitrogen. Albuminoid.	Nitrogen. Nitric and Nitrous.
Crude Sewage	26,64	8,9	2,71	6,33	...
Average anaerobic tanks laboratory	9,63	8,0	6,33	1,45	...
Average 1. contact laboratory	3,71	8,1	2,69	0,63	...
Average 2. contact laboratory	2,39	...	1,82	0,53	0,44
Average model percolating filter laboratory...	2,72	8,1	...	...	present
Average 1. contact field installation	14,15	7,3	1,15	2,07	...
Average 2. contact field installation	3,51	6,4	0,76	0,95	0,22

On the whole the results tend to show that better effluents are finally obtained if anaerobic decomposition is first resorted to. It must be remembered however that the primary aerobic bed in the field installation is really the equivalent of the anaerobic tank and therefore a third contact would be necessary for strictly comparative results. At the same time it is clear that the effluent from the anaerobic treatment, imperfect as it was, owing to the conditions of experiment already described is yet further purified than the effluent from the primary aerobic bed. Moreover the experimental contact beds, receiving the effluent from anaerobic treatment, were filled as a rule once per day instead of once every 5 days as was generally the case with the aerobic installation. No doubt the installation could have been worked at a somewhat higher rate but special experiment showed that if the same bed was filled many days in succession the purification rapidly decreased.

It would appear therefore that purely aerobic treatment is specially adapted, as already suggested, for temporary installations, where a period of heavy working is followed by a prolonged period of rest. In dry weather it will be necessary at such times occasionally thoroughly to moisten the filters with water.

In practice no doubt the construction of watertight contact beds will not be necessary. In the experiments above described they were made use of for purposes of accurate control. The simplest arrangements will probably be some form of dosing tank, discharging on to percolating filters, the upper portion of which are constructed of coarse material. The solids will be retained and gradually disintegrated in this portion, while the liquid will percolate through and be purified in the lower part of the filter, which may be made of material of smaller dimensions.

The sterilisation of effluents.

An effluent of the character of that produced from the percolating filter above described, though chemically excellent, cannot in the light of experiments shortly to be mentioned, be considered as fit, from a bacteriological point of view, to be discharged into a stream which may be used in the near vicinity for domestic purposes. If possible, therefore, the effluent should be used for flushing the latrines connected with the anaerobic tank, and thus little or no effluent need finally be discharged at all. In this way economy of water will be effected and moreover by interaction of the nitrate in the effluent and the organic matter in the sewage it has been shown that a certain amount of nitrogen will be eliminated in the gaseous state. Where such a procedure is impracticable however the question of sterilisation has to be carefully considered.

A number of researches have been made during recent years, indicating that hypochlorites in some form or other are the most suitable form of sterilising agent for use under these circumstances.

In this connection several important questions presented themselves, *e.g.*

1. Is it possible to dispense with such a treatment by adequate filtration of the effluent?

2. How far is the amount of sterilising agent required dependent on the quality of the effluent ?
3. What effect, if any, is the addition of chloride of lime likely to have upon the water into which the effluent flows ?

1. In relation to the first question some interesting experiments were made with the effluent from the continuous filter already described.

In the first place it was found that in a 5-gallon native sewage there were from 8 to 14 million organisms per cc, capable of growing on agar at 40° C. including about 1 million "bacillus coli communis."

In a fairly good latrine effluent about 500,000 organisms were found to develop on agar per cc.

A number of determinations were made both of the total number of organisms capable of growth on agar at laboratory temperature (averaging about 35° C.) and of the number of "coli" as determined by MacConkey's method, in the latrine effluent and in the filtered effluent respectively.

The results varied a good deal from day to day but agreed in showing a total reduction of about 30 to 50 per cent. and the same reduction in the number of "coli."

That is to say, although, as has been shown, the samples were chemically excellent more than 10,000 "coli," organisms were still present per cc.

The following special experiment was undertaken later to see whether on still further oxidation of the filtered effluent by repeated passage through the filter a greater reduction in the number of organisms could be secured.

For this purpose the filter was put out of action and allowed to run dry. Eight gallons of the tank-effluent were then passed through and the filtered effluent sampled at the top rate of discharge. The drainings were thus omitted from the sample but as far as possible these were collected and re-filtered. This operation was repeated four times. Each time about 1 gallon was lost, giving a total loss of 4 gallons.

The results are given in the following Table and show that a progressive reduction, both in the total number of organisms, and in number of "B. coli" took place.

	Oxygen absorption parts per 100,000.		Total colonies.					Coli tested with MacConkey Medium.					
	4 hrs.	3 min.	1	2	3	4	Average.						
Unfiltered tank effluent ...	0,94	0,32	148	168	205	234	18 900	1/5000 +	1/10000 +	1/16000 +	1/20000 +	1/25000 —	1/30000 —
1. filtration ...	0,22	0,14	67	76	76	56	6 900	1/500 +	1/1000 +	1/2500 +	1/5000 —	1/20000 —	
2. filtration ...	0,16	—	15	30	17	53	2 900	1/300 +	1/500 +	1/612 +	1/825 +	1/1000 —	
3. filtration ...	0,10	0,08	14	9	9	7	1 000	1/2 +	1/10 +	1/50 +	1/66 —	1/100 –	1/10000 —
4. filtration ...	0,04	0,02	312	340	520	634	449	1/2 +	1/10 +	1/30 +	1/50 —	1/200 —	

Although such a method of eliminating pathogenic organisms could not be recommended for obvious practical reasons the experiment is of interest as showing that, with progressive improvement in the chemical purity of the effluent, there is a corresponding improvement in the bacterial purity. It appears therefore safe to assume on general grounds, that when an effluent is discharged into a stream and undergoes further oxidation therein the organisms characteristic of sewage pollution will also diminish in numbers.

2. In regard to the second question a number of experiments were made which showed clearly that the amount of chloride of lime needed for effective sterilisation is much reduced as the purity of the effluent increases, a few grains per gallon being all that is needed in the case of a thoroughly oxidised effluent. This is of course to be expected, as it is well known that the more nearly the conditions approach those in which the "naked" organisms alone is submitted to the sterilising agent, the more efficient is the action of the latter.

3. To answer the third question a number of experiments were made which showed that any small excess of chloride of lime which might pass into a stream very quickly disappeared under the combined effect of dilution and sunlight. It was found that dilute solutions of chloride of lime on exposure to tropical sunlight lost their "available" chlorine with extraordinary rapidity.

It may be concluded therfore that every effort should be made to produce an effluent by ordinary filtration processes of the highest possible quality. In the writer's opinion it would be unsafe to assume (in the absence of exact knowledge of the action of hypochlorites on the complex organic matter of sewage) that an effluent imperfectly oxidised by natural agencies could be rendered

harmless by sterilisation. The admission of appreciable amounts of chloride of lime to a stream might also have injurious effects on the microscopic or "plankton" life of the river, the results of which are not always easy to foresee.

If, however, effluents are produced by properly constructed and carefully managed installations, comparable to the effluent already referred to, and if, further, a period say, of 2 hours in a small "insolation" tank is allowed between the addition of the chloride of lime and the admission of the sterilised effluent to a stream, then it appears inconceivable that any injurious effect could be produced upon the latter while at the same time the effluent would be in a sterile condition.

GENERAL CONCLUSIONS.

The foregoing descriptive outline of the experiments undertaken shows that, under tropical conditions, even highly concentrated sewage can be efficiently purified.

General method.—In general the most suitable treatment will be preliminary fermentation in anaerobic tanks followed by final oxidation in precolating filters of fine material.

Design and management of tanks.—Special care is needed in the design and management of such tanks. In particular the capacity must be carefully considered in relation to the number of users rather than the volume of the sewage. It is desirable where possible to "inoculate" a new tank with deposit from a tank already in satisfactory operation.

Utilisation of gas.—The gases evolved from such tanks are mainly derived from the decomposition of cellulose, and by taking certain precautions it is possible economically to utilise such gases for lighting and power purposes.

Rate of filtration.—The effluent from tanks in satisfactory operation can be purified on percolating filters at ordinary European rates, and therefore the area of filters necessary need not be excessive.

Aerobic methods.—It has been shown that satisfactory purification can be obtained, if the conditions remain essentially aerobic throughout. Such a method of treatment would appear to find its application chiefly in installations of a temporary character, or as a standby to deal with sudden increases of flow.

Final treatment of effluents.—Where there is danger of bacterial pollution at the outfall, it is advisable, where possible, to utilise the effluent for flushing latrines. Where this procedure is impossible sterilisation by hypochlorites can be readily accomplished, and if certain precautions are taken no difficulties need arise at the outfall on this account.

The conditions referred to or dealt with in the preceding pages cover most of those which are likely to be met with in tropical countries. It is hoped therefore that the work described may be of general value to those engaged in improving sanitation in such parts of the world.

THE PRIMARY TREATMENT OF SEWAGE.

By W. J. DIBDIN, F.I.C., F.C.S., &c.

The attention of sewage purification experts in the past has been too much confined to the attainment of a suitable effluent, while the really more important because more difficult point of the disposal of the solid matters has been relegated to the separation of the sludge in tanks as a malodorous, non-hygienic mass. The subsequent treatment of this abomination by spreading over or digging into ground or by pressing into cake and burning or burying is equally expensive and unhealthy. The writer has been of opinion for a long time that these processes are quite unnecessary and illogical. His experience in connection with the purification of the Thames showed that the natural aerobic processes at work in the water and on mud banks as well as in ponds and small running streams are capable of effecting the inoffensive destruction of large quantities of organic matter. It is essential however that the rate of supply should not exceed the feeding power of the various organisms which under proper conditions will continue their beneficent operations indefinitely. The residuum from such natural action is harmless and approximates to the nature of the mother earth.

The study of the action taking place naturally under conditions of moisture and aeration led to the conception of the original contact beds. In those beds designed for the treatment of crude sewage the coke or clinker was of large size, so that the solid particles of sewage matter could penetrate into the interior of the bed through channels formed by the interstices of the material. When such a bed was filled with crude sewage and allowed to rest quiescent for an hour or two perfect sedimentation in the first place occurred by the solid particles falling on the material. Secondly by the action of gravity between particle of coke and a particle of finely suspended matters substances in partial solution were retained on the coke. When the water was withdrawn the retained solids were exposed to the incoming air which followed the lowering of the water level. The result of these alternating conditions of moisture and aeration was the rapid development of aerobic organisms and the organic waste matters were used as food by not only bacteria but higher organisms such as the infusoria and annelida. The digestive processes of the enormous colonies of creatures which developed reduced the solid sewage to an inert residuum or "humus."

In consequence of the aerobic conditions being maintained as far as possible no nuisance occurred.

It was anticipated that when the humus should accumulate to such an extent as to seriously impair the capacity and drainage of the bed it would be

necessary to renew the coke or other material or to wash and replace it in the beds periodically. It must be remembered that the process was intended to supplant the older costlier methods of chemical precipitation and sludge burial so that the cost of renewing or washing the coke would have been slight when spread over a number of years in comparison with the cost of chemicals, etc.

The choking of the beds, especially in installations where hardly sufficient capacity had been provided to allow the organisms full opportunity to effect the destruction of the solids, presented a more serious feature than was anticipated, especially in view of the fact that simple sedimentation tanks used before the contact bed lengthened the life of the material very considerably. The writer, in view of the enormous advantage of the contact action, as it was called, devised a bed in which a series of plates were employed in place of the particles of coke. Experiment showed that this bed was not only satisfactory in result but also economical as by reason of their greater capacity beds so constructed would treat twice the volume of sewage per unit of cubic content as beds of coke or clinker.

The difficulty of obtaining suitable plates at an economical price was overcome by using slate debris obtained from the slate quarries. This material, which has an irregular cleavage, is unsuitable for roofing purposes but is highly satisfactory as a material for sewage disposal beds.

The first beds thus constructed were made at Devizes with the result that the working cost of sewage disposal at that town has been reduced from £700 to £200 per annum. The complete absence of nuisance both on the works and in the interior of the beds is one of the most satisfactory features. The residual humus which escapes from the slate layers with each discharge is collected in the channel which receives the effluent and may be retained and swept on to a special drainage plot or passed on to the surface of the fine beds whence it can be raked periodically after having had time to dry. In either case the dried residue is comparable in appearance, smell and composition to fine garden mould.

Originally it was anticipated that at some time the humus would accumulate and the slate require flushing in order to restore the capacity. In practice however after treating the extremely foul and heavily charged sewage of Devizes for three years the deposit on the slates is no greater than it was after only six months work. It appears that the discharge of humus is equivalent to the increment of solids with each dose of sewage less the matters destroyed in the beds. The quantity of humus measured on the large working scale obtainable at Devizes in three years amounts to less than one-thirtieth of the total solids introduced into the beds. The latter figure is computed from the amount of sludge pressed in three years at these works prior to the introduction of the slate beds.

The explanation of the action is that natural processes are simply applied under artificial conditions in a confined area. Each slate layer is really a mud bank charged with all manner of aerobic organisms below and including the annelids. As long as the supply of food for these organisms is maintained in just proportions to the air supply so long must the destruction of the organic matter continue without nuisance or accumulation of foul sludge.

Experience of the system has now been gained under many conditions. The sewage at Devizes is exceptionally heavy with slaughter-house refuse, brewery waste, &c., whilst that at High Wycombe is on the other hand very weak. At East Dereham steep water from the malt houses equals about one-third of the sewage flow: at Ash in Kent brewery refuse is in great excess; experiments with the Romford sewage containing a large proportion of brewery waste have given good results whilst normal domestic sewage is being satisfactorily treated in a large number of cases. At Trowbridge a large variety of manufacturing waste renders the sewage quite exceptional, yet special experiments made under the direction of the Trowbridge Council showed that, in the words of Mr. Waterfall, F.I.C., &c.: "slates gave the best results." At the Gouripore Jute and Oil Mills near Calcutta an installation has been at work for about two years with satisfactory results according to report and it may be of interest to members of the Congress that such an installation is available for inspection although the conditions of climate, food supply, &c., are different from those in England.

From the results accomplished it is clear that the sludge trouble, nuisance and expense are things of the past where the slate bed system is in use. The secondary or even tertiary treatment of the effluent from the slate beds may be accomplished in any one of the now well-known methods, but if it is desired to effect the work in the absence of nuisance either from smell or distribution of sewage organisms in the atmosphere, or from cultivation of enormous numbers of flies, no better method than land treatment or its artificial substitute "contact beds" can be obtained.

THE ACTION OF A SLATE BED.

By W. J. DIBDIN, F.I.C., F.C.S., &c.

Many otherwise experienced authorities on sewage disposal have expressed a difficulty in grasping the principle of the action which takes place on "Plate Beds," commonly known as slate beds, in consequence of that material forming the most convenient and economical form of plate. It is therefore with a view to making the process clear to those who have not followed biology in relation to the life processes at work

in river water, tidal mudbanks, &c., that the following detailed account of some experiments which I have made is set out as clearly and succinctly as possible :—

The idea which some apparently have that the destruction of waste organic matters must be due to purely direct physical and chemical causes seems to be the main stumbling block. As a matter of fact the work accomplished is purely the result of digestion. On looking at a mass of the deposit on a slate which has been employed for some time in a bed the casual observer would notice nothing but a collection of *dèbris*, which is forthwith dubbed "sludge" and off-hand, relegated to

Place a portion of the deposit on a small piece of slate, about 3 in. or 4 in. square for convenience, or other suitable support, and warm it very gently by applying heat to the undersurface. A considerable movement will soon be seen to take place on the immediate surface, and gradually a heaving mass of minute worms will struggle to escape from the heated under-layer. These are clearly aerobic organisms whose power of digestion is considerable, and it is to a great extent their casts which form the inoffensive humus which escapes from the slate layers with the effluent, thereby preventing the accumulation which is the cause of the choking of the old course contact beds.

Experiments on the Rate of Destruction of Solid Matters in Slate Beds, prepared with Deposit taken from the Slates in the Beds at Malden, Surrey.

Substance.	First day, after 20 hours' rest.	Second day.	Third day.	Fourth day.	Fifth day.
Bread ...	Zooglea masses, starch cells, spiral vessels, motile bacteria, leptothrix, green confervæ, &c. Bread undergoing disintegration.	Numerous bacteria, starch cells very attenuated and losing form.	Bread completely disintegrated, abundance of leptothrix, oscillaria, monadina, clostridium, quantity of round granular matter, query worm casts.	—	—
Butter ...	Mass of fat cells ...	Fat cells with brown granular matter (? worm casts.)	Brown granular matter with spirilla, leptothrix, fat cells.	Irregular cellular membrane with colonies of micrococci and bacilli, &c.	Butter reduced to a thin wafer.
Cheese ...	Masses of various bacteria, *i.e.*, bacilli, micrococci, streptococci, &c.	Swarming with colonies of motile bacilli.	Bundles of stellate crystals interspersed with numerous bacteria, motile and nonmotile.	Fat cells crowded with bacilli and diplococci.	The cheese reduced to a thin pasty layer.
Lettuce ...	Chlorophyll attacked, bacilli, diplococci zooglea, leptothrix, &c.	Peaty matter, various bacteria.	Granular matter, leptothrix, various bacteria, monadina, amœba, infusoria, &c.	Indefinite *debris* (? worm casts); lettuce decomposed to granular condition almost free from bacteria (? action of worms).	Last trace of lettuce disappeared.
Lean pork ... (cooked)	Mud black underneath, deep chocolate on surface various bacteria, leptothrix, and encysted infusoria. ? worm casts.	Meat in fibrous state, muscular fibres embedded in zooglea masses of bacteria, large numbers of spirilla and motile bacilli, anguillulæ and worms.	Muscular fibre extremely attenuated, numerous spirilla, motile bacilli, and monadina, zooglea, oscillaria, &c.; the whole swarming with micrococci.	Muscular fibre entirely destroyed, the residue being alive with motile bacilli, spirilla, monadina, oscillaria, anguillulæ, worms, &c.	Pork reduced to a thin greyish scum consisting of various organisms.
Tendon from roast pork; very hard and tough.	Abundant organisms, various bacteria single and in zooglea form.	Enormous numbers of micrococci and monadina.	Swarming with micrococci, spirilla, monadina, granular cellular matter (? worm casts), fungoid mycelium.	Quantity of brown granular matter (? worm casts), anguillulæ, worms, monadina, many bacteria, zooglea masses, oscillaria, &c.	Tendon reduced to a soft grey mass.
Fat of ham ...	Leptothrix, streptococci and numerous zooglea masses.	Fat cells interspersed, with various bacteria.	Fat cells, brown granular matter (? worm casts), bacteria, &c.	Fat cells with zooglea masses, spirilla, &c., various infusoria, opalina, oscillaria, &c.	Fat largely reduced to a soft pasty mass.
Brewery refuse in sewage	Yeast cells practically destroyed, leptothrix, zooglea masses, various infusoria.	All odour of brewery refuse disappeared, grey surface deposit.	—	—	—

that category, thereby denoting the foul accumulation of matters obtained in a sedimentation tank of the ordinary pattern. On smelling the mass, however, it is at once realised that it differs from ordinary sludge in that it is inoffensive On allowing a portion to dry it does so rapidly and without the production of offensive emanations given off by "sludge."—

These two facts point to a difference, and invite closer examination. This may be conveniently made as follows :—

Next take a fragment from the surface of the deposit by touching it with the point of a wire and place it on a microscope glass slide with a droplet of water, covering the whole with a thin glass cover in the usual manner. Now examine this with a $\frac{1}{4}$ in. or higher power. It will be at once seen to be largely made up of innumerable living organisms of great complexity and variety, other than the worms.

From these simple examinations it will be evident that instead of an inert mass of matter we have a hive of

ctive and voracious living organisms, from the lowest type of bacteria up to the highly organised worms, larvæ, &c., which, like a collection of animals in a zoological garden, feed upon the daily supply of food given to them, and so long as this supply is steadily and regularly maintained, so long will they perform their life functions, and in so doing destroy the waste organic matters which, in their collective form, we call sludge; the process involved being merely that of digestion—the waste products of one group being but food for a lower.

matter is nothing but an enormous number of bacteria, many in a state of restless activity where they are not crowded in zooglea masses which prevent their rapid movements.

Continue these observations from day to day, each day flooding with water and draining after two hours or so. In a few days the solid particles of meat, &c., will become invisible and merged in the mass of black humus into which it is finally resolved.

It is evident that this is precisely what takes place in

Experiments with Deposit collected from Slates in Bed treating the Sewage at a Private House.

A preliminary microscopical examination showed that the deposit was swarming with minute red worms, anguillulæ, infusoria, and various bacteria.

Substance.	First day.	Second day.	Third day.	Fourth day.
Lean of raw beef...	In four hours the red colour had turned to grey.	The beef had sunk into the mud, grey in colour, and swarming with bacilli, spirilla, monadina, &c.	Beef scarcely visible, being now one mass of various organisms.	Meat entirely disappeared.
Cheese	In four hours the cheese was light grey in colour.	Cheese had sunk into humus, swarming with bacilli of various kinds.	Cheese reduced to a thin layer.	Entirely reduced to a pasty condition.

On November 2nd, 1908, 7 grammes of the raw liver were placed on a layer of the above deposit, laid on the bottom of a 4 in. Petridish, the area being 12 in. approximately. The quantity of liver thus treated was equal to the treatment of a sewage 100 times normal strength.

First day (after 24 hours).	Second day.	Third day.	Fourth day.	Eighth day.	Fifteenth day.
Liver had lost colour, odour unpleasant.	Odour offensive...	Very offensive ...	Odour decidedly reduced.	Odour had entirely disappeared.	Liver reduced to a very few resistant pieces, which were covered with whitish grey spots consisting of bacillus megatherium. Later, a growth of the mould, mucor caninus, developed.

NOTE.—This experiment was very drastic. The liver was laid very thickly, with scarcely any room between the pieces, none of which was smaller than $\frac{1}{16}$ in. diameter, whilst many approached $\frac{1}{2}$ in.

On November 6th another dish was similarly charged with 1 gramme of beefsteak raw, 1 gramme of beef fat, and 1 gramme of cheese. On the sixth day the cheese had entirely disappeared, the beefsteak was reduced to a greyish soft mass, and the fat was disintegrated.

The process may very conveniently be watched from day to day by placing the previously mentioned small piece of slate in an ordinary plate or saucer, and putting on the "living earth" on the slate small fragments of meat, bread, &c., and flooding the plate with water gently so as to completely cover the whole. After an hour or two gently decant the water from the plate so as to thoroughly drain the plate and deposit thereon. Leave it freely exposed to the air, preferably in a moderately warm atmosphere. On watching from time to time it will be seen that the piece of red meat has become coated with a grey deposit, this being often complete in four or five hours. Now touch the grey matter with the point of a wire, and transfer the minute quantity thus taken up to a miscroscope slide as before, and examine under a high power, when it will be seen that this grey

a slate bed. When the bed is first filled with sewage, and allowed to stand full in a quiescent state for a couple of hours, the solid matters settle on the slates. Until the "living earth" is fully developed, the destructive action is slow, but in warm weather especially the organisms rapidly develop and attack the food thus provided for them, exactly as the organisms in a river mud attack the matter deposited thereon from a tidal water receiving sewage matters, and if the ratio of organisims, food and air supply are properly regulated, the action proceeds indefinitely without the evolution of nauseous odours.

The account given in the Tables of a series of experiments made to ascertain the rate of destruction of various foodstuffs when placed on the mud on the slates will be of interest.

SOME RECENT ASPECTS OF THE SEWAGE PROBLEM.

By W. D. SCOTT-MONCRIEFF.

To those who are acquainted with what has been going on during the last twenty years in connection with the subject of sewage disposal there are several landmarks that stand out with some clearness in the midst of much obscurity. Although England has been the pioneer and far in advance of any other nation as regards sanitation, I think it is to the illuminating genius of Pasteur that we are chiefly indebted for an explanation of nearly all that has recently been accomplished by those who have invoked the forces of Nature, unaided by the use of chemicals, as a final solution of the sewage problem.

Compared with his monumental labours the contributions of all the other workers put together seem almost insignificant, and yet, so far as I know, he never made the subject of sewage-disposal his special study.

It is always right to draw a distinction between the work of those who have only made suggestions in general terms and that of others who have succeeded in proving their contentions by facts obtained from painstaking and elaborate experiments. From this point of view the achievement of Pasteur is transcendent. If he had not undertaken the work there was no one else to take his place, and, but for his courage and ingenuity, exercised at a critical moment, the celebrated experiment of Pouchet would have left Liebig and his followers in possession of the field, so that the doctrine of spontaneous generation might have survived as a scientific dogma of the present times.

When Mueller, in 1865, stated that the putrefaction of sewage was not a process of chemical self-reduction, but was due to the work of organisms and analogous to digestion, he hit upon the real nature of what occurred, but if Pasteur had been asked the question he could have given an identical answer from what he had discovered in his work upon fermentation, which had been carried out nearly ten years previously. In the same way if the invention or discovery of the "Automatic Scavenger" of Mouras had been referred to Pasteur, he could have explained its working from observations and experiments he had made nearly twenty years before it had been thought of.

The real interest of the Mouras tank hinges upon the arrangement by which the incoming sewage is discharged through a depending pipe or dipstone, so that it does not mix with the sewage on the surface but with the enzymes or ferments of liquid that has already been hydrolised. This principle has never been fully exploited and for many years I have urged the importance of doing so.

The first attempt to apply the process of putrefactive hydrolysis in England in practice was by means of a ultivation Tank in my Ashtead experiments in 1891, and the idea of it occurred to me, not from a study of the work of Pasteur, but simply from the observation of what took place in long lengths of sewers, where a liquefying process must be at work in order to allow of the conveyance of organic solids to long distances from the points of discharge, especially in cases of insufficient fall.

At the time referred to the Massachussets Board of Health had already been carrying out a series of elaborate experiments dealing with the effects of downward filtration upon fresh sewage, and I believe I was the first to point out the advantage to be obtained by following Nature, and arranging for a putrefactive fermentation to precede the nitrifying changes which occur under highly aerobic conditions in percolating filters.

The first attempt to realize this sequence was by means of nitrifying channels, and it is unfortunate that I should have been unable to discover a better method until 1897, when the contact-bed had already come into vogue without a scientific investigation of any kind having preceded its adoption.

Although the septic tank as introduced by Mr. Cameron at Exeter is a distinct landmark and did much to advertise bacterial treatment as a practical method of sewage disposal, it is now generally admitted that this device was only an embodiment of the Mouras tank in another form, and I am convinced that the putrefactive process is still capable of great development.

From the scientific standpoint, it may still be regarded as almost in its infancy, and I have had repeated occasion to refer to the extraordinary absence of any exact information as to the best period during which the putrefactive fermentation should be carried on so as to obtain the greatest amount of molecular instability for any particular sewage, because this knowledge is essential in order to arrive at the proper amount of tank capacity required in every case.

It was only last year that I had an opportunity of making a series of experiments for a Committee of the Surrey County Council, the results of which appeared in a paper I read at the Sanitary Congress at Cardiff last July. From these it appears that, with a well-arranged percolating filter, there is quite a wide range in the periods of retention in a Cultivation Tank which may occur without seriously interfering with the quality of an effluent. This is a subject, however, about which it is dangerous to make generalisations and each sewage should be tested separately in order to obtain reliable results.

With these general observations it may be well now to say something about a landmark which has appeared quite recently in the shape of the fifth and most important report of the Royal Commission on Sewage

Disposal, which has been at work during the last ten years.

My own view of this Commission may best be explained by supposing that the problems involved in the production of vinegar, the discovery of the causes of anthrax and rabies and the diseases of vines and silkworms, together with their remedies, had all remained more or less in the hands of empirics, aided by ordinary practitioners, and that a commission had been appointed to report upon lines similar to those set forth in the reference to the Royal Commission on Sewage Disposal, as to the best methods of dealing with the difficulties involved in the solution of these obscure and complicated problems unaided by the genius of Pasteur.

The amount of printed matter produced by such a commission might have been enormous, especially if they had included the evidence of everyone who professed to know something of the subjects involved in the inquiry, but it is not difficult to realize what a miserable failure the output of such an investigation would have been when compared with the achievements of the one man who published little but did all.

In the light of these observations it is no great disparagement to the Sewage Commission to say that their work has been in many respects disappointing, for the simple reason that there has been no one with a genius comparable to that of Pasteur to help the Commission to anything better than a vast collection of undigested and uncorrelated facts.

Seeing that no member of the original commission had made any special study of the subject previous to his appointment it is not surprising that they should soon have found themselves involved in an inextricable tangle of conflicting evidence from which it was impossible for them to escape without the aid of the same gifts that enabled Pasteur not only to discover his clues, but to follow them with unerring steps to a final solution of each and all of the problems referred to.

Having failed in their methods they have failed all along the line, and I do not speak so strongly from any desire to undervalue the work that the Royal Commission has accomplished, but because I am afraid that their report will be an incentive to many persons to get out schemes, involving the expenditure of much money, upon a very slender foundation, and whatever the results may be that it will always be easy to point to some portions of the Report as a justification for what they have done.

It seems as if we might almost go further than the instance of Pasteur, and find a closer analogy for the present position of the sewage problem by supposing that a commission had been appointed to report upon the possibilities of the steam engine without ever having decided upon a universal standard of measurement and comparison such as Watt's units of foot-pounds and horse-power.

It appears to me that, from a scientific standpoint, the Royal Commission have left the sewage problem exactly as they found it. If the highest results, such as those obtained in the Ashtead experiments and at Caterham, had been taken as the starting-point in the treatment of ordinary domestic sewage with such a standard as 90 per cent. of oxidised to 10 per cent. of unoxidised nitrogen in an effluent, it would have been an obviously scientific method of procedure to go on to discover the difference in the conditions that gave less favourable figures. The best methods must then have been confined to those that gave the nearest approach to the high standard already reached. This line of investigation would have been all the more important when it is realized that it would have been in the nature of a deliberate effort to reach the true and final solution ot the problem, not only by obtaining the highest standard of purity, but by the conservation of the fertilizing qualities of the sewage in one and the same operation.

It will be noticed that so far from recognising the importance of this method of procedure the Royal Commission have omitted to make any reference to the Ashtead experiments, and have made no comment upon the results obtained at Caterham, although in both cases there was as much as 9 parts per 100,000 of nitric nitrogen in the effluents, which represents an almost perfect plant food in combination with the other residuals. Seeing that the nitrification referred to is about four hundred per cent. higher than the average of all the results put together which have had the careful consideration of the Royal Commission, it appears as if they have turned their backs upon the only line of investigation that was worth serious consideration.

The results obtained at Ashtead and Caterham* might well have been used as a clue to a solution of the problem seeing that it was only necessary to identify the factors in terms of accurate measurement in every case and then to discover what the discrepancies were that accounted for differences in results.

During many years I have never been contradicted, so far as I know, with regard to the proposition that, in downward filtration, and omitting the element of temperature, which, in practice, may be taken as question of climate, there are four and only four factors to be dealt with for any given grading of a suitable filtering medium. These factors are : First, the rate of flow, or quantity of liquid treated per unit of time ; second, the period of rest required between each discharge of liquid upon filters ; third, the quantity of air needed for the oxidising work of the organisms, and, fourth, the depth of filter necessary for the production of any required standard of purity, when the other factors are properly adjusted. Seeing that the difference of strength between the Ashtead and the Caterham sewage was as much as three hundred per cent. and that the latter was the strongest that came under the notice of the Royal Commission, the results must remain valid through a wide range of organic pollution. It follows, therefore, that if there really are only the four factors referred to entering into the problem at all, then if these can be accurately measured, the difference be-

* The results of the Ashtead experiments will be found in Dr. Rideal's Sewage and Sewage Purification and the Caterham results pp. 88-108-109-132-133-136, Fifth Report of the Royal Commission on Sewage Disposal.

tween the cases that give results up to the highest standards and those that fall short of them cannot only be accounted for, but the factors themselves ought to be capable of adjustment so as to bring all the results into line.

My contention is that the figures should be worked out for each individual case before any heavy expenditure is incurred at all, and I must confess that my principal reason for satisfaction at the appearance of the last report of the Royal Commission is that, now that they have had their say and are leaving everything much as they found it, there is some chance of getting matters put upon a more rational footing, which hitherto has been impossible while all the world was waiting for the deliverance.

If it should be urged that the Ashtead experiments were made with superimposed trays that are not feasible in practice, this objection is nothing to the point, because if the causes of difference in favour of the Ashtead results as compared with any others can be discovered either in the air supply or in the three remaining factors, it then becomes the business of the engineer in some way to realize the required conditions if he is to reach the best standards at all.

In the face of the almost total absence of any kind of scientific method and of any provision by which different experiences can be correlated, it is not to be wondered at that the most widely divergent views should exist as to the methods that should be adopted. The final solution of the problem must consist in completing the adjustment of the relations between the Animal and the Vegetable Kingdoms by which the vital functions of both are permanently maintained, as stated by Warrington nearly sixty years ago. This truism has been totally disregarded in England and looked upon in recent years as little better than a dream, while the nitrogen of the sewage, which Sir William Crookes has estimated to be of the value of £16,000,000 per annum, is thrown into the sea without an expression of regret. I understand that matters are on a very different footing in India, and that the idea of conserving the manurial value of the sewage is an element in every scheme which involves bacterial treatment.

Before concluding it may be well to make some reference to a matter that has not been raised by the Royal Commission in their report, but which is of the greatest importance. It amounts to this: that in the opinion of those who are responsible for safeguarding the public health there is no objection to the spraying of vast quantities of septic sewage during high winds in the neighbourhood of densely populated cities. It naturally follows that, from a health point of view, there can be still less objection to the same sewage in a less septic condition being left to itself in a river. In other words for all practical purposes the question of river pollution in England in many cases is a matter of sentiment only and not one that can in any way endanger the public health. If this had been explained beforehand it is doubtful if Parliament would ever have passed the River Pollution Acts, at any rate in their present form.

DISCUSSION.

Lieut.-Colonel Dyson, I.M.S., in initiating discussion on the papers, said that they were of great interest to sanitarians in India. The questions of sewage were cropping up in India and the experience of sanitarians in Europe and the results of their experiments carried out in some of the large towns at great expense were likely to benefit them in India. Mr. Maxwell's paper on the sewage disposal was particularly interesting. The disposal of sewage in his opinion should not be subservient to financial considerations.

Mr. G. B. Williams, Sanitary Engineer, Bengal, said that owing to the very short time he had had to read through the papers his criticisms must be taken as just expressions. He considered more evidence had not been brought forward regarding Indian sewage disposal works for he understood that a considerable amount of information with regard to the working of the bacterial system in this country was now available.

He agreed with Mr. Maxwell as to the advantage of Preliminary experimental work in certain circumstances but uttered a word of caution with regard to generalising too freely from insufficient data.

He considered Mr. Maxwell's statements with regard to septic tanks misleading. The septic tank had not proved itself an unnecessary evil, although it had not fulfilled the glowing anticipation of its introducers. It was only capable of reducing the suspended solids in a sewage by from 10 to 30 per cent. and the tank effluent sometimes contained as much as from 15 to 20 parts per 100,000 of suspended solids. Nevertheless, when the filters were composed of coarse material and the question of sludge disposal was a serious one, the septic tank might have an advantage over the sedimentation as chemical precipitation process went over the usual alternatings.

The Royal Commission on sewage disposal had come to the conclusion in their first report that a cubic yard of filtering material arranged as a percolating filter would purify twice as much tank effluent as the same quantity of material in a contact bed, so the latter system was not likely to be much used in future works.

The removal of fine suspended matter with effluent from the percolating filters was undoubtedly necessary but he had not himself been in the habit of providing such elaborate arrangements for this purpose as the author.

Every one must recognise the valuable pioneer work done by Mr. Dibdin during the early stages of the introduction of the bacterial system but nevertheless it was an undoubted fact that his contact bed had not fulfilled his expectations and before expressing an opinion on the slate beds he would like to see analysis of the sewage before and after treatment.

With regard to Mr. Fowler's paper Mr. Williams remarked that the chief trouble occasioned by the discharge of crude sewage into tidal estuaries was the pollution of shellfish and after his experience of the attitude of the Board of Trade with regard to the matter he doubted whether there were many places where an occasional discharge of a very large quantity of a mixture of sludge and water would be permitted if there were any possibility of such pollution.

Finally in respect of Mr. Scott Moncrieff's remarks he suggested that it was not altogether surprising that that gentleman considered the Royal Commission on sewage disposal a complete failure seeing that they had not agreed with him, but he doubted whether any important person who studied the various aspects of the vast amount of independent investigation undertaken by those experts would be of the same opinion.

Professor Knaolph said he shared with Mr. Williams the regret that more evidence had not been forthcoming giving Indian experience of septic tanks and other methods of sewage treatment. He felt that there were reasons for suspecting that septic tanks in India were not quite analogous in their working to those in England and colder climates. For this reason it seemed important to investigate the working of septic tanks in India and for this reason the two septic tanks, which had

recently been erected at the Indian Institute of Science, Bangalore, had been so arranged that they could be used for experimental works. He hoped in this way the omission, Mr. Williams pointed out in his paper, based on Indian experience, would be rectified.

Major Clemesha, I.M.S., Sanitary Commissioner, Madras, commenting on the same papers said that it was impossible to compare the result obtained by septic tanks from English sewage and apply them to Indian sewage and again that was not the only criterion Very much depended upon the nature of the sewage and the definite amount of nitrogen present. Without this data it was not possible to construct a septic tank Nitrification and its definite relation to temperature was useful to a certain extent. It was found in Madras that all surface water contained practically no nitrates. This was probably due to the nitrifying organisms not surviving the high temperature of India. Some adequate arrangement should be made for the removal of sludge from septic tanks. He thought the percentage of sludge given by Mr. Williams was too low particularly if the population were a vegetable eating one. In connection with Professor Rudolph's remarks as regards septic tanks, it was his experience that sullage was more difficult to deal with than sewage.

Dr. Newell then said that, of the leading features which modified the design of sewage works in India, in his opinion, the temperature of the environment and the degree of concentration of sewage met with seemed to be the most important. Purification by biological methods following nature's methods offered the best solution for a purified effluent. Usually the process was explained, as Mr. Maxwell did, by attributing the action to anaerobic and aerobic organisms. He believed that this was a mistake and the purification of sewage by biological methods was effected as in nature by three kinds of bacteria in order, *viz.*, anaerobic, then facultative organisms and finally aerobic. That was to say that first anaerobic organisms acting in the absence of air disintegrated the larger organic particles into simpler bodies, and gradually the sewage was acted upon by organisms which accustomed themselves to either anaerobic or aerobic conditions and finally other organisms which were truly aerobic, acted only in the presence of air. The inorganic matter was not offensive and being mainly mineral was got rid of chiefly by the grit chambers or sediment tanks. If the sludge difficulty was the main difficulty to a proper working of biological works, as he believed it was, then he could not agree that septic tanks could be done away with. It was not necessary that they should be covered, neither was prolonged septic action in all cases desirable, and in this country the period of retention in septic tanks could probably be much lessened. Mr. Maxwell admitted that filters might become clogged and he (the speaker) was not sure that Mr. Maxwell's "preliminary preparation tank" would entirely prevent contact beds or filters from becoming clogged, any clogging would give rise to trouble and imperfect affluents. If septic tanks in India were covered in the rains they would become reservoirs and in the hot weather would be liable to become offensive and therefore the fastidious native labourer might object to use them.

In his opinion the best results would be obtained by having (1) a grit chamber for separation of inorganic debris ; (2) a septic tank for anaerobic action to prepare the sewage for such subsequent action ; (3) upward filtration through contact beds for action of facultative organisms ; (4) downward filtration through contact beds for aerobic action; and (5) passage upon percolating filters. In place of 5 might be substituted land filtration. Special sewage containing particular wastes might require one or more of these points to be modified, and perhaps preliminary chemical treatment, and he agreed that "double contacts" would secure better results where the expense was permissible. Lastly the passage of the affluent over aeration traps, he said, must be regarded as a satisfactory process.

Dr. Goldsmith, Assistant Health Officer, Bombay, asked whether septic tanks had anything to do with the breeding of mosquitoes. He made the enquiry as mosquitoes had been discovered in the septic tank at Malabar Hill.

Major Clemesha, explained that the septic tank at Ootacamund had a wooden roof and he thought this was desirable because people thought they got a smell from septic tanks if they could see them In Madras they had, he stated, had no trouble in respect to mosquitoes but they had found that the trickling beds bred flies. This was a great disadvantage in this country. What happened was that the trickling beds became a mass of maggots and bred flies.

Dr. Jehangir J. Cursetjee remarked that in connection with the incidence of mosquitoes in the Malabar Hill tank he believed that it was stated in a Corporation meeting that the mosquitoes had disappeared since covers were placed on the tank. That was the assurance given by the Health Officer to the Corporation.

Dr. Goldsmith replied that he had made the report while acting Health Officer of Bombay, but it was subsequently as a matter of fact even after the covers had been put on that larvæ of mosquitoes were found. He had then used a strong disinfectant, a curious anomaly to use a disinfectant in a septic tank. We wanted a septic action and yet we had to use an antiseptic. The Devon County Lunatic Asylum septic tank failed because disinfectants were used in the Asylum which filled the anaerobic microbes.

Mr Williams said that in Ismalia it was found that mosquitoes were breeding and spreading and yet they could not find out where. It was eventually discovered that they were breeding in the cesspools. These were covered up and only had a ventilation pipe. It was through this ventilation pipe the mosquitoes got out. These pipes were covered with gauze netting and the nuisance disappeared.

Dr. Nair (Madras) questioned as to the septic tanks in the Jute Mills at Calcutta said that he believed they were doing good service and were discharging excellent effluent into the Hoogly. There was a great deal of agitation in Calcutta on this subject and it would be interesting to see how it ended.

Major Clemesha said that in his experience the effluent was very good indeed.

Dr. Sukhia said he was not present when the discussion was going on about septic tanks but he had heard Dr. Goldsmith contradict the statement made by Dr. Jehanghir that putting covers over the septic tanks at Malabar Hill had stopped the breeding of mosquitoes in them. He declared that the report that they had had remained uncorrected by Dr. Goldsmith and the Health Officer Dr. Turner. Bombay City suffered from mosquitoes owing to the bad state of the drains and an insufficient sewage system. These septic tanks were a serious danger to the public. With regard to the septic tanks which were constructed very recently, it was, because the inhabitants living close by, threatened litigation that the municipality took the precaution to cover them up. He said it was unfortunate to say the least that Dr. Goldsmith had not informed the Corporation that the effect of putting covers over the tanks had not stopped the breeding of mosquitoes.

TOWN REFUSE DISPOSAL

By W. H. MAXWELL, A.M. INST. C.E.,

Borough and Waterworks Engineer, Tunbridge Wells Corporation.

The sanitary disposal of refuse collected from amongst human habitations will readily be recognised by a medical congress such as the present to be a matter of primary importance and a first step towards the building up and maintenance of a high standard of public health. In a temperate climate like that of England it is rightly regarded as a cardinal point in all sanitary work, but amongst populated centres in tropical latitudes cleanliness and freedom from refuse matters of all kinds is even more essential to the public well-being. (In submitting the following few notes it will only be possible to shortly touch in outline some of the more salient features of the question as it presents itself amongst sanitary authorities at the present day).

By the expression "town refuse" is understood what may be described as domestic household refuse with, in most cases, some limited admixture of trade or shop refuse, and, in many districts, small proportions of vegetable or garden refuse. The chief methods employed for this disposal of such materials from towns may be very briefly summarized as follows :—

1. Depositing upon waste or low-lying land, filling of pits, excavations or raising the level of marsh land, such sites being temporarily described as "tips" or "shoots".
2. Mixing household ashes, dust, etc., with pail excreta for the purposes of their common disposal by sale or otherwise to farmers for agricultural purposes.
3. Selling or giving away to brickmakers.
4. Mixing with sewage sludge and ploughing or digging into the soil of sewage farms.
5. Mixing with precipitated liquid sewage sludge, or with pressed sewage sludge-cake, and cremating in destructor furnaces.
6. Crushing or pulverising the refuse by machinery and employing the resulting product as a manure or in the manufacture of fuel with an admixture of tar.
7. Riddling, burning cinders, and vegetable refuse to generate steam, and using the fine dust in connection with a manure manufactory, the old iron being sold, and the pots, etc., used for the foundations of roads.
8. Selling by tender yearly.
9. Barging away down canals to country districts.
10. Taking out to sea in hopper barges and sinking refuse in deep water, as done at Liverpool.
11. Utilising by "sorting" by hand or by machinery and selling the ingredients for use in such trades or manufactures as can employ them, as done at dust contractors' yards.
12. Destroying the crude refuse by fire in destructor furnaces, and utilising the residual clinker and surplus steam for various purposes.

The methods of disposal selected in different districts depend largely upon local circumstances and conditions, but very commonly the cheapest plan available has the preference. Oftentimes this may be but a mere make-shift, and the means of disposal for many years may be nothing better than a hunting about from one make-shift to another, until at last, all other means having been exhausted, a specially built refuse destructor becomes an absolute necessity.

During the last 40 years the *destructor system* has had its birth, has grown into maturity, and has latterly been pursued to an extent which has enabled the practice to be reduced to certain now well understood general principles. Experience has led to the design of efficient types of destructors, has shewn what is the true calorific value of average town refuse, so that manufacturers are now able to give definite and reliable guarantees of performance such as both users and makers may, with a reasonable degree of certainty, expect to fully realise.

Of late years many improvements have been made in connection with the destructor system of dealing with refuse. Some of these may be shortly stated, thus :—

1. The maintenance of high temperatures within the cells, combustion chambers, etc., ranging between 2,000° to 3,000° Fah., and the reduction of air leakage into the cells.
2. Improvements in the durability of the furnaces under high temperature, and the avoidance of defects caused by contraction and expansion owing to frequent variations of temperature.
3. The use of forced draught and hot-blast and the reduction of power consumed in its working.
4. The extraction of the full calorific value from the refuse, and the interception and utilization by means of boilers, economisers, or feed-water heaters, superheaters, regenerators, hot-blast draught, etc., of all heat given off by its combustion, and the fullest possible application of the same to the performance of profit-yielding work.
5. Improvements in the generation of high-pressure steam and the maintenance of steady steam pressures, but with means of affording a certain amount of elasticity of output, as by thermal storage, or storage of refuse fuel.
6. The reduction of labour costs involved in the handling of the raw refuse, in the stoking

and charging of the furnaces, and in the removal and disposal of clinker, fine ash, etc.

7. The introduction of all possible means of fu'l utilization of residuals created at the works, such as clinker, fine ash, solder, or other marketable material from the refuse.

8. The perfecting of various necessary plant employed in the utilization of residual clinker, etc., as in the manufacture of paving slabs, carriage way pitching blocks, building bricks and tiles, mortar, and graduated clinker for sale.

9. Sanitary improvements in connection with the handling and storage of the refuse, and the prevention of dust or smells from the tipping platform, chimney shaft, or elsewhere.

10. The reduction in capital cost in the erection of destructor works.

For many years past there has been a growing confidence in the utility of modern destructors as *power producers* in addition to being mere destroyers of refuse, as evidenced by recent combined installations at such districts as Liverpool, Nottingham, Wolverhampton, Preston, Hackney, Bermondsey, Fulham, Plumstead, Woolwich, and others. From recent results of several London combined destructors and electric stations it appears that the money value of the refuse fuel per unit of electric current generated varies from about ·7*d* to ·9*d* per unit, and that under ordinary working conditions from 20 to 40 units per ton of refuse are at present obtainable, but that over limited periods much higher outputs have been generated. But, in the investigation of the value of destructors to electric or other power stations, one of the main difficulties is that of procuring trustworthy statistics on an *uniform basis* such as can be usefully compared one with another.

The quantity, or rate at which refuse is burned by a modern destructor, very commonly lies between 50 lb. to 60 lb. per square foot of furnace grate area, and the cost of dealing with the refuse on this system varies on the average as follows :—

	s. *d.*		*s.* *d.*	
Labor of burning and handling, including stokers, feeders, yardmen, etc.	0 8	to	1 10	Per ton of refuse.
Supervision, repairs, removal of clinker, stores, water, rates and taxes	0 6	to	0 9	Do.
Capital charges (interest and redemption)	0 6	to	1 9	Do.
	1 8	to	4 4	Per ton of refuse burned.

There has been much difference of opinion in many quarters as to the advisability of installing refuse destructors in conjunction with power using stations of various kinds, but, generally speaking, it may be stated that where there is refuse which *must* be disposed of and works to which some form of motive power *must* be supplied, experience has shewn that the modern refuse destructor is of a certain real commercial value as a power producer, and that, where suitable conditions exist, the outlay involved in its application to that duty is generally justified by the results obtainable, not forgetting, at the same time, its useful sanitary function as a means of refuse disposal.

THE DISPOSAL OF REFUSE IN HILL STATIONS.

By Lieut.-Col. W. BEEVOR, C.M.G., M.B., R.A.M.C.

It is surprising how many people seem to think sewage and general refuse can be effectively disposed of on some common plan. Nowhere is the fallacy of this conclusion more plainly illustrated than in Hill Stations. Sewage disposal having occupied a considerable amount of my professional time for some years, I am anxious to give this Congress some of my experiences in Indian Hill Stations. Superfluous would it be for me to enumerate the various processes in use throughout the civilised world to such a learned community as this Congress represents, so I will come direct to the point and give you my experience of the various methods. There can be no gainsaying the fact that the bactericidal destruction of refuse is the proper one, but local conditions regarding water-supply do not always admit of it. Still I am of opinion that the future will see this system universally adopted. My contention is that the saving in fuel and light will compensate for expense of outfit and machinery for water-supply. In this country, the general refuse of a community will render from 3·5 to 4 cubic feet of gas per diem for every human being: this gas will light the houses and streets, and run gas stoves of sufficient calibre to cook the food of the community, with a small surplus for hot water baths and gas engines. Anyone doubting this assertion may see it carried out at the Matoonga Lunatic Asylum near here. Mr. James, late Sanitary Engineer, designed as good an installation for that Asylum as I have seen anywhere in Europe. Now, the advantages of a system yielding such a useful commodity as this gas would save our Hill Stations vast sums of money in fuel, both wood, coal and oil—the transport of these necessities is in itself a serious consideration. In Dalhousie during the late rains, it was impossible, at times, to procure sufficient oil for lighting ; and we consumed large amounts of wood, whilst we were wasting the resources of Nature in permitting useful gas to escape into space. Further, a water-carriage system of drainage is much preferable to any dry removal ; and every Hill Station possesses sufficient fall in its occupied areas, to permit of a perfectly constructed organization.

I am therefore favourable to the bactericidal destruction of refuse, and, concluding its well-known details are familiar to you all, I will not weary you with their description. But we must, for the present, face the fact that the day has not yet arrived in which sanitarians can persuade those controlling the Nation's purse strings to grant the necessary outlay for installing this most natural method of refuse disposal; and my next point for you to consider is "how best to temporise?"

I unhesitatingly condemn the trenching system for Hill Stations, the soil is mostly sandy, the crust very thin, with underlying rock, and vegetation so abundant that the digging of proper trenches is an impossibility; the removal of sewage from bungalows and barracks, situated on steep inclines, is extremely disagreeable, and very dangerous, for sweepers cannot be expected to carry out the necessary precautions during the rains; shallow trenches cannot be constructed, for they are rapidly filled with water and washed away; the hill sides are slippery, pathways rugged and sweepers constantly fall when conveying "bhaltis" on their heads; and lastly the nitrifying organisms are very scanty in forest soil.

We had an extremely disagreeable experience at Dalhousie last year of the results of what used to be called "deep trenching"—this is nothing more than a system of kutcha cess-pits. Mankote Barracks had apparently emptied their refuse into hundreds of cess-pits, from 4 to 7 feet deep, excavated out of the sides of the northern slope. A new officers' mess had been decided upon, close to this slope; but, when a road was being dug to the site, some of these cess-pits were opened, with most interesting results to us, sanitarians. Scarcely any nitrification had taken place, the stench was appalling. I saw in several pits fæcal deposits that had not even become disintegrated. Eggshells, potato peeling, paper, and even bits of cabbage, merely fermenting and stinking. You will naturally enquire "how old were these pits." None were less than 12 months and one row was declared by the head sweeper to have been dug by him 2 years ago! Some were even older than this and showed more change in their contents, but none were effectively destroyed. Now, this presents a problem of what I consider great importance to sanitarians. If you go on defiling your surroundings in this way, how much undefiled ground will a large community have in its vicinity in a few years? Needless to say, our Brigadier-General Kitson, than whom there is no better sanitarian, stopped all work on the slope I have named. But I know of hundreds of other cess-pits in the Dalhousie vicinity, both Civil and Military areas. As I have just said, General Kitson is a keen and up-to-date sanitarian; he very kindly allowed me to experiment with many systems of refuse disposal and we came to the conclusion that failing the bactericidal one, which we both favour, none could be trusted but those which employ fire to ensure complete incineration.

The type of incinerator is becoming rather a heated question. Scores of us have what we are pleased to call, "*invented*" our own. All have modified the systems of others until the air simply crackles with the praises each man lauds upon his own. In my humble opinion, we have not yet arrived at the type which adapts itself to the requirements of all localities—different installations fulfil different requirements. Where native sewage has to be dealt with, a very serious element comes in, *i.e.*, the enormous volume of sewage water to be got rid of, and the only incinerator which has successfully overcome this difficulty, in my hands, has been the open gridiron pattern (illustration). You will admit that the following comprise the main features of successful incineration—(*a*) absence of smell, (*b*) rapidity of destruction, (*c*) complete incineration producing innocuous ash, (*d*) facility of change of position, (*e*) economy in fuel, (*f*) proximity to latrines. Any one installation, possessing all these qualities, I have not yet seen, but the two which have worked best have been the gridiron, just described, and the English Army Field pattern (description). It is maintained by some that the direct removal of fæcal matter, from the pan to the incinerator, is a *sine qua non*, but I have not yet seen a Native Bazaar where this can be practised. Small latrines must be sanctioned in some places, and around Barracks it is absolutely necessary to place latrines for Natives, otherwise they will defile the ground—incinerators cannot be placed at each of these. If the mixing with horse and cow litter is carefully done, no harm accrues. The "Raites" Incinerator has many admirers and is a very good system, in some places, but it certainly does not produce an ash that is free from organic matter, and in rainy weather requires too large a cover to suit Hill Stations.

DISCUSSION.

Dr. M. B. Cama, L. M. & S., said that he wished to allude to the tenth mode of the disposal of town refuse referred to in Mr. Maxwell's paper, namely, taking the refuse out to sea in hopper barges and sinking it in deep water as was done at Liverpool. Bombay the beautiful was surrounded by sea on all hands and was provided with all the means of ready transit such as trains electric trams motor waggons, Renard trains, &c., and he thought that the method recommended was quickest, cleanest and safest and above all the cheapest mode of removal of town refuse and he wondered why it had not been thought of before by the City Fathers. It seemed to be more attractive to rush after costly chemical schemes to the neglect of the simple and natural means so well suited to Bombay's environment

Professor Norman Rudolph asked at what spot at sea it was proposed to deposit the rubbish and imagined that if the deep sea were intended the ordinary hopper barge would not be able to do the work in the monsoons when it would be difficult to get men to go out with the barges.

Major Clemesha said he thought it was quite possible to carry out this suggestion even during the period of monsoon weather and witnessed the instance of the carriage of sludge from Manchester to Liverpool where it was taken out and deposited in deep water, despite the terrible dangers that were run in connection with South westers and gales. The Bombay monsoons, he thought, were not to be compared to these and he thought if specially designed steam barges were built that this would be by far the cheapest and best means of the disposal of the City's refuse.

Refuse was made up of two types—rubbish that could be used for manure, and fœcal matter which come from the septic tanks, which was of no use at all. In his opinion the best and most satisfactory way of disposing of town refuse in villages and towns of 15 to 40,000 inhabitants was to fill up all hollow places in the land. In Madras the Municipality got Rs. 70,000 per

annum from the contractors for the City's refuse. Another method which was sometimes adopted in small towns was to give the refuse to the contractor free on condition that he removed it to a suitable distance and this saved a large portion of the expenses of the Municipality. It was not in his opinion a very satisfactory method as the contractor was not always amenable to reason, and small heaps of manure were generally found hidden about the City limits. There was no doubt he said that the best way to dispose of combustible matter was to put it on the ground.

Dr. Jehangir J. Cursetjee said that the City Fathers had given considerable attention to the question of the removal of the City's refuse and night-soil into the sea and many reports had been submitted as to the most suitable manner of disposing of the city's refuse. The problem was a difficult one and the cost of disposal now involved was most prohibitive to a large City like Bombay. Ten thousand tons of refuse had to be disposed of and the expenditure per annum was calculated at Rs. 22 lacs out of an income of only one crore of rupees which was bound to deter any enthusiasm in the breasts of the City Fathers in regard to any experiments in this direction.

Dr. Rudolph had pointed out the difficulty of using hopper barges in the monsoon and wished to know whether it was feasible. The matter had been seriously considered and it might be feasible to send barges out, but the harbour tides were against the suggestion being adopted. It was at one time proposed to dispose of the refuse in the deep sea of the Prong's Lighthouse at Colaba, but as there was a Military Cantonment there, Government objected and the extraordinary tidal currents were also against the possibility of the scheme being successful.

Mr. G. R. Williams said he was interested in what the last speaker but one said about the use of town refuse. In Egypt he had found it of not very great manurial value. On the other hand, he did not think that Mr. Maxwell allowed for the difference between London and tropical refuse. In 60 per cent. of the London refuse there were half-burnt cinders and ashes which made it of a highly combustible nature. This was not the case in Indian refuse which to a large extent was composed of damp matter. He stated that the Foreign Office had sent him to Zanzibar to report on the disposal there and he found that it was not possible to burn the refuse so saturated as it was with moisture. In order to burn it, it was necessary to burn dry wood fuel with it and nothing like the heat power was obtained from it as from London refuse.

Mr. Pearse (Health Officer of Calcutta) referred to the fact that the majority or nearly all modern refuse destructors had been constructed for the destruction of European town refuse which was of a very different character to that of Indian cities The latter consisted largely of vegetable refuse and could not easily be burnt, and all the incinerators so far tried had been practically failures even with the aid of fuel and forced draught. He threw out the suggestion that the town refuse of many Indian cities might be passed through heavy steel rollers somewhat after the manner in which sugar-cane was treated, in order that all the watery contents might be passed out and allowed to go into a sewer while the remaining solid or dry material could be easily burnt. The cost of refuse disposal, unless ground were to be reclaimed or fertilised, was absolutely unremunerative and it was very advisable that some method should be adopted to avoid the enormous costs which were now incumbent upon municipalities. Refuse destructors must be modified if they were to suit Indian conditions.

Dr A. D Cooper, D.P.H. (Baroda), said that he had not intended to say anything, but one or two statements had been made about town refuse which he thought required correction. Kattchra or town refuse, in his opinion, had no manurial value. In Baroda, Ahmedabad and other parts of Guzerat the ryots would not take it away even if given some slight monetary consideration for doing so. He therefore used it for filling up low lying hollows. On the other hand, he said that night-soil stored on a different footing was of manurial value to every municipality.

Major Clemesha said that his experience in South India was otherwise and that a large proportion of the cultivators from the Malabar Coast were glad to get the refuse for cultivation purposes.

Dr. Mirza, Health Officer, Hyderabad, said that in towns and districts dry street sweepings only should be sold to contractors for using as manure either after burial or after keeping it on the fields and flooding the fields to rot the rubbish On this manure paddy was sown, or after fairly drying it any other crop could be sown. Another use for dry rubbish was to use it as fuel for brick kilns ; this was done after sifting; a third use was filling pits but in this case after depositing the rubbish it ought to be fired ; this could easily be done all through the year by a man constantly raking the rubbish and another setting fire. He had done this even in the monsoons. This would prevent, to a great extent, putrefaction and the percolation of its products or the dissemination of gases.

Dr. K. E. Dadachanji (Bombay) said that they had heard that it was generally thought that incinerators would not prove a success in India owing to the moisture contained in the garbage and also on account of the presence of various solid materials such as brickbats &c The Bombay Corporation had considered the question off and on and it was thought inadvisable to put up an installation, in the first place, because it might have created a nuisance in the neighbourhood in which it was erected, and secondly because it would not work efficiently with damp garbage, especially in the rainy season. The question of the speedy removal and destruction of the town refuse of Bombay had become so pressing, however, that the City Fathers had again to give the subject of incinerators consideration recently Dr. Turner, Health Officer of Bombay, when on his last visit to England, studied the recent improvements in the construction and efficiency of incinerators and had recommended the use of the Horsefalls Incinerator of the tub-feed type which did not create any nuisance and it mattered little whether the garbage was moist or dry. The Municipal Executive Engineer had concurred with the Health Officer and it was expected that one of these incinerators would soon be erected in Bombay for experimental purposes. If the results proved satisfactory four installations of the Horsefall incinerator would be erected in Bombay, in points some distance from the Flats. The cost of this would be about 4 lacs of rupees but they would not do away with the present arrangement of the carriage of garbage by Railway to Deonar.

The question of the removal of night-soil by barges was considered several times, but the cost appeared to be prohibitive, besides the Government would not allow the creeks leading to the sea to be silted up. Again it would be very difficult to run barges in the open sea in the monsoon as Professor Rudolph had already said even if the City of Bombay were disposed to defray the cost of maintenance charges for such barges.

Dr. Nair (Madras) said that in Madras Rs. 20,000 were paid by contractors for town refuse. In regard to refuse and incinerators he stated that the rubbish on that side was very dry and the reason why incinerators, he thought, did not work well in Madras was because the brickbats of which there were a large number present in the town sweepings filled up the furnace holes and prevented the efficient working of the incinerators.

Dr. J. A. Turner, Health Officer, Bombay, said that to make a bad joke the incinerator question was a burning one. Things had come to a crisis in Bombay and the Corporation had decided to adopt a trial. The present system was to collect the refuse by means of one thousand five hundred carts and by them one thousand tons were disposed of, each bullock cart carrying about 8 cwts. of dry refuse. In the monsoon even though the refuse was damp by the time it had reached Deonar by Railway it was comparatively dry. The problem in Bombay was to collect and destroy all this refuse. The difficulty of destroying refuse by incinerators, he thought, was over-estimated. He had seen every kind of refuse destroyed in incinerators in England. In India the refuse was much more combustible than was generally thought and he did not expect any difficulty in destroy-

ing refuse in the Horsefall Incinerator even in the monsoons. The only point for consideration was whether the reclamation of land with refuse was not more pro-table than incineration which would give little or no return. But in India it was not expected that there should be much return from refuse. He was of opinio that on the whole a good system of incinerators would be far more economical than the procedure now adopted. He saw no possible objection and no reason why the refuse of large cities could not be de. stroyed by incinerators. As the previous speaker had already stated it had been decided to set up a Horsefall Incinerator in Bombay as an experiment. He explained that one of the advantages of this particular incinerator was that it was tub-feed and the refuse could be put into it without being touched by hand. The Horsefall Incinerator, he said, was working successfully in other tropical cities and he therefore did not anticipate any trouble in connection with its satisfactory working in Bombay.

He showed an illustration of a Horsefall Incinerator installation and explained that the picture showed that though it was working in the midst of populous middle class dwellings at Bradford there was no nuisance from it.

Dr. Ma hew, D. P H. (Madras), wished to know whether one of these particular incinerators had been erected at Liverpool as he recollected Dr. Hope ta-ing round such an installation and he was struck by the fact that there was no handling of the refuse.

Dr. Turner stated that the incinerators at Liverpool and Bradford were Horsefall Incinerators.

Dr. Mathew said that to his mind dumping city rubbish on low lying grounds and tanks was a good method of disposal of city rubbish if suitable sites were available, as by so doing two good purposes were served, namely, reclamation of the ground and disposal of the refuse. If such dumping were covered over wi h a thin layer of earth or silt little or no nuisance was likely to result.

Incinerators in spite of their drawbacks still held a place among rubbish disposal works. In Madras the incinerators were by no means failures although they had not come up to the expectations formed of them in the beginning.

Dr. Nair (Madras) said he wished he could share the optimism of Dr. Turner in regard to the success of incinerators. So far as his experience went incinerators were failures in India. The calorific value from dry rubbish in India was quite different to that in England. In Madras it was expected that the incinerators would drive an engine and pump from the heat generated, but it was found that the incinerator could not generate sufficient heat to perform this function and the engine had to be driven by other power. On the principle once bitten twice shy they in Madras would keep quiet till the experiment Dr. Turner was going to make with the Horsefall Incinerator had been carried out and reported upon. He agreed with Dr. Turner that the removal of dry refuse by bullock cart was a difficult and slow operation. In Madras also they had a slow and costly process. He thought it would be a good thing to utilize the Tramways, and that Municipalities should stipulate with Tramway Companies to have running power at night, and from where the Tramways ended there should be light railways to carry the refuse away to a distance from the city. There would of course be the side streets not served by the Tramways and there of course bullock carts would be used to convey the refuse to various points of the Tramway system. If some such system were adopted the systematic and efficient removal of dry rubbish might be effected. The present system adopted by large Municipalities was, he thought, most insanitary and very unsatisfactory.

Dr. D. B. Master then rose to read the paper on "Defects of Sewage Disposal in Bombay" contributed by himself and Dr. J. J. Cursetji.

He prefaced the reading of his paper by remarking that he wished at the outset to remove any impression that might arise that any of their remarks were directed against any individual. They were made generally with the idea of improving the sanitation of the city of Bombay which was certainly in a very bad state. Their intention in submitting their paper was not to criticise the conduct of any individual officer or any particular department for faults of omission or commission but to see their beloved city in which they had been born and bred and in which they had passed the happy days of their lives, rendered sanitary. They did not think that the fair name of the city should go down to posterity and the world at large as Unhygienic Bombay but as Healthy and Hygienic Bombay. If they were obliged to make remarks which might prove unpalatable they were sure they would be forgiven as they were made in the best interests of the city.

NOTES ON SOME OF THE

CHIEF DEFECTS IN THE PRESENT MODES OF DISPOSAL OF THE SEWAGE AND TOWN REFUSE OF THE CITY OF BOMBAY,

(Including the Evils arising from their Imperfect Working and their Possible Remedies),

BY

Drs. JEHANGIR J. CURSETJI, M.D., L.R.C.P., L.R.C.S., L.M.&S., FELL. ROY. SOC. OF MEDICINE, London;

AND

DINSHA BOMANJI MASTER, L. M. & S., Hon. Physn. to the Insane Parsis' Fund.

The City of Bombay was considered only about two decades ago a fairly healthy city in India, and compared very favourably with other larger Indian towns in point of sanitation and general cleanliness. Its death-rates were, comparatively speaking, much lower than of most of the other Indian towns, not excluding even the Presidency cities of Calcutta and Madras. It possessed a fairly good and comparatively pure supply of water for its inhabitants, from its three large lakes, the Vehar, the Tulsi, and a little later, the Tansa, and owned extensive water works, the largest and the most costly of their kind, not only in India, but, perhaps, in the whole world. It had already adopted the most approved principles of the water carriage system for the removal

of its sewage at an exceedingly heavy expenditure, and possessed a fairly working system of conservancy. The expenditure upon its Public Health Department was considerably more than of any other city in India, it had a fairly equable temperature and moderate rainfall, and, above all, was beautifully situated on a fine seashore, open on the west to the health-giving breezes from the fair Arabian sea. So that all the health-giving factors were already there. In fact, it has been and is still in every respect the pioneer city of India, having enterprising and intelligent citizens, and being ahead of most of the other cities in adopting the latest and newest measures for its sanitary improvement. And yet, notwithstanding all these natural and acquired advantages, it has, of late years, and especially since the advent of that most troublesome scourge, the plague, within its precincts, acquired an evil reputation for extreme unhealthiness, as evinced by its high death-rates, following in the wake of various diseases.

It might well be asked, "Why is it so, and what is it that makes it so?" The question is not so easily answered as asked, because it is not one or two causes merely, but a combination of various direct and indirect disease-producing factors that constitute its present ill-health and unhealthiness. We have discussed some of the more important of these causes at some length in another paper, contributed to this section of the Congress. We will, hence, only consider here what we think to be two of the most important factors amongst them, *viz.*, the defective modes of removal of (1), the city's sewage, and (2), its town refuse, and the best methods for their removal and ultimate disposal.

(1) Taking up *the disposal of sewage* first, the greater part of the city is drained into the system of main and branch sewers which terminate at Love Grove, where the sewage is pumped into the sea. Some portions are as yet undrained, and schemes for dealing with these districts have been under consideration, or are formulated, while some others are already being sewered at present. But it will still be a considerable time before the whole city is fully drained. Most of the sewage of the portions of the city already sewered, is carried to Love Grove, where it is pumped into the sea outfall by means of four triple expansion Worthington engines, each engine being able to pump 15 million gallons in 24 hours, to an average height of 26·54 feet. Three of these engines only are used at the same time, the fourth being laid off for cleaning and repairs. The sewage is discharged into two sewers of each 3′-6″ in diameter, which are carried along the foreshore to a point 700 yards north of the pumping station, where two lines of cast-iron pipes three feet in diameter convey the sewage to a depth of six feet below the lowest spring tide. The carrying capacity of these two outfall sewers is 4.142 cubic feet per minute, or 37·278 million gallons per 24 hours, when not surcharged. This system of drainage is based on the most approved principles of sanitary science, *viz.*, the water carriage system of the present day. But it cannot be said, by any stretch of imagination, that, as it has been worked hitherto, it is all that it should be and could be. There are various glaring defects in it which are apparent even to the most superficial observer, and do not require any very deep study to find them out. From the very fact of the intolerable nuisances they create, not unattended by grave risks and even serious danger, they have become so irritating to the public mind that they require the most prompt attention at the hands of the Municipal Executive.

It has been long a matter of popular belief, perhaps born of a practical experience of the working of the sewerage system of the city for the last 20 or 25 years, that the sewers constitute one of the chief factors in the causation and propagation of various diseases, and especially some of the bad and obscure types of fevers prevalent in Bombay. The official reports submitted to the Municipal Corporation by its Health Officers and Executive Engineers from time to time, and the special reports by specially paid expert advisers like Messrs. Baldwin Latham, Santo Crimp, and Midgley Taylor, are in themselves more than a sufficient indictment against our faulty sewerage system and lend considerable weight to this popular belief.

It must be acknowledged that the water carriage system of sewerage, if it possesses all the conditions necessary for its proper working, is by far the best method of sewage removal. At the same time it must also be acknowledged that it is on the rapidity and efficiency with which the sewage matter is removed, that the health of a town having such a system will largely depend. For the safe adoption of this system for a tropical city like Bombay, therefore, three things are very essential, *viz* :—

(*a*) A sufficient and constant water-supply for thorough flushing.

(*b*) Well laid water-tight sewers, with a proper gradient, sufficient ventilation, and carefully made house connections.

(*c*) A properly placed outfall, with adequate pumping power.

All these absolutely necessary conditions are unfortunately not present in our present water carriage system. Besides, it is not possible to escape the admission that the way in which this system has been worked, all these years, is against some of the most accepted principles of sanitary engineering and even against the ordinary rules of common sense. (*a*) There is not enough water to be had for domestic purposes, much less for the thorough flushing of the water closets and the sewers. Even this scanty supply is irregular and intermittent. The majority of the old storm water drains are flat-bottomed and worn out, allowing the sewage passed into them to stagnate and percolate through their cracked sides and leaky bottoms. They thus allow the subsoil to be badly saturated with polluted matter, and also constantly contaminate a very large number of private house wells used for drinking purposes.

(*b*) Some of these old sewers are badly laid, badly jointed, badly worn out, and with a bad gradient in

many places. They are connected on the faulty principle of invert to invert. Some of them are not water-tight. Some again not of the size and gradient that would ensure even a bare flushing velocity for their highly putrefactive and dangerous contents.

Their *ventilation* is not satisfactory, and the appliances expressly adopted to ventilate them, instead of serving that purpose, often act as so many channels for forcing back the sewer gases into houses, and poisoning people in their own bed rooms.

Some of the *house connections* have also proved very *unsatisfactory*, and, owing to choked pipes and loose joints, they have often afforded easy ingress to sewer gases into houses.

A large number of these *pipe sewers* are "*choked*," or *obstructed*, time after time, according to the quarterly reports of the Drainage Engineer himself. They have often to be broken open before the obstruction can be removed. Again, many of these, as well as some of the larger sewers, are more or less constantly filled with silt, and surcharged in consequence. *To obviate frequent choking* of these drains and sewers, *large cesspools or catchpits* are constructed at various points in the heart of the town *to intercept solid sewage.* This is not at all desirable, as it violates the first and foremost principle of the water carriage system in allowing the accumulation of rapidly decomposing sewage matter, for days and even weeks, which ought to run out at once from the start to the outfall. *The present pumping power at the Love Grove station being inadequate, there is naturally a more or less chronic surcharging in them,* more especially during morning and evening hours, when the consumption of water in the city is at its highest. This state of things (surcharging) was known for many years, even when Dr. Weir was the Health Officer. And yet this serious defect has not been remedied even until now. Everyone of these statements can be proved from the official records of the Municipal Executive Officers themselves, and can be strongly corroborated by the personal observations of the experts specially called in to help to remedy this peculiarly unpleasant state of things.

Owing to this constant surcharging, *many of the sewers are in a leaky condition.* A late Special Drainage Engineer, Mr C. C. James, says, in his report on this surcharging of the sewers, "The evil of putting our sewers under great pressure (due to surcharging) is much more far reaching than would appear at first sight. My experience is that a sewer under a pressure of 8 feet of head, as some of ours are at present, will leak freely, and pollute the soil for a considerable distance on the side. In the case of Bombay sewers, this appears to a greater extent than would usually be the case, because Mr. Rienzie Walton, in constructing them, did not plaster the inside of the Arch, and consequently the sewer water can freely pass out under great pressure. I have no doubt the cement of our stoneware pipes leaks freely in many parts of the city. The result of such pollution is that noxious gases are formed and drawn out by evaporation to the detriment of the general health." This report was penned somewhere in the year 1901. We are not aware that, except for a few spasmodic repairs, any very sustained effort has been made, during the seven years that have since elapsed, to remedy this dangerous state of things, and it is possible our old sewers and drains are in just as leaky a condition, if not worse, in the year 1908, as they were in the year 1901.

With regard to *the accumulation of Silt*, the same Officer, with a grim, almost cynical humour, generated and developed by constant association with such a state of things, admits, that "the silt will always be with us, and, as we cannot hope to greatly alter the habits of the poor classes, we must recognise the silt in our sewerage system." Why, in the name of common sense, should not the engineer advisers of the Corporation and Government, when they first planned our present sewerage system, have "recognised" the peculiar habits of the people, rather than be obliged to bemoan this "recognition of silt" at this very late stage of its working? What a sorry confession, indeed, to have to make, for the Drainage Engineer of the city himself. The poorer classes must of course be allotted their full share of the blame attaching to this state of things, and for thus "misusing the sewers" and choking them up. But the peculiar habits and customs of the people born of sheer ignorance and stupidity must have surely been known to the Municipal Executive for ever so many years. And yet this important factor was not considered of sufficient moment, it seems, to be taken into serious account by our Municipal Officers. This should most certainly have been done, in order to ensure the proper working of such an entirely new system, adapted for the first time to the needs of a tropical city like ours, and where such decomposing silt and sewage stagnation from surcharging spells disease and death, even in a much greater degree than in a temperate or cold climate. The Municipality cannot therefore get out of their full and just share of condemnation.

Coming now to a discussion of our *defective Storm Water drains*, as a natural corollary to the discussion of our defective sewers, many present here will be surprised to learn, that, unlike every other city in the world with a water carriage system of sewage, most of our storm water drains serve the double purpose, like poor Goldsmith's solitary chest of drawers, of "a bed by night and a drawer by day," and act as carriers of sewage matter and even night-soil during the dry weather, *i.e.*, during eight months of the year, and a mixture of storm water and mixed night-soil and sewage matter during the remaining four months of the monsoon! In this connection Mr. Baldwin Latham, in his "Sanitation of Bombay" (1890), tells us: "Having regard to excessive rainfalls that occur in limited periods in these districts, above all things, it is essential that the rain as far as possible shall be preserved in all its natural purity, and be conducted by itself to the nearest natural outlet, and that under no circumstances shall

rain be permitted to mingle with the sewage and other polluted waters of the districts, and that all channels by which rain flows away in the monsoon period shall at all times be preserved and carefully guarded against pollution of every kind." This is certainly most excellent and unexceptionable advice in theory. But how does it come out in actual practice in our city? For an answer, we cannot do better than quote our present energetic Health Officer, Dr. Turner's own testimony. In one of his reports on the conservancy of the city he tells us: "The present system of storm water drains is very defective, as into most of them sewage is discharged. They are practically sewers, and as such very deficient and dangerous to health. They are constantly blocked, and for this reason have to be opened and cleaned." This was in the year 1901. We are afraid we have not advanced much since then in improving this most deplorable, unscientific, and absolutely insanitary state of affairs, and people are in consequence being slowly but steadily poisoned in their bedrooms, as much now as seven years ago. Our present Deputy Executive Engineer, Drainage, furnishes even a more curious and astonishing reading on the strange working of our storm water drains. In a letter to the Municipal Commissioner regarding the examination of these drains, he says: "There are some 200 miles of storm water drains in the city. It is very desirable that a thorough examination and survey of all the storm water drains should be undertaken, as many of them being very old undoubtedly require repairs. Moreover the majority have no manholes on them, and their exact position is in many cases unknown. It is not unlikely even that there are drains still in use of which all trace has been lost. There are no accurate plans of the positions of the storm water drains on the Municipal records, and this is a further reason why it is desirable that they should be surveyed." Reasons indeed! one cannot help asking if there could be a more humiliating confession of such an un heard-of state of affairs in this the first Municipality in India, with an annual income of over a crore of rupees, and an annual expenditure very near that sum.

As if so much blundering was not enough, one more yet remains for our consideration, which possibly caps them all in very seriously enhancing the unrelieved difficulties of the situation. And that is the extremely *faulty location of our present Sewerage Outfall.* According to Mr. Baldwin Latham "so far as Bombay is concerned, if it is to get the greatest advantage from its sanitary works, it must dispose of its sewage neither on the West nor on the North of the city, and that all liability of polluting either the earth or the sea should, if possible, be most carefully avoided in this direction. The direction of the current points distinctly to a position south of Bombay as the most appropriate for a sea-fall." Mr. Santo Crimp is of the same opinion. Mr. H. A. Acworth, a former able Municipal Commissioner, in his History of the Drainage and Sewerage of Bombay, says: "The eastern outfall had been condemned on the strength of some float experiments which I have already referred to, and which seemed to lead to the conclusion that the sea current at ebb tide set into the harbour and at flood tide out of it. I cannot but share the surprise expressed in 1890 by Mr Baldwin Latham (pages 34 and 35 of his report) that conclusions so opposed to the order of nature should have been accepted without suspicion. As Mr. Latham says 'Who can believe that Bombay Harbour empties itself on flood tide and refills on ebb tide? To my mind the whole thing is a mistake.' The enquiries on the subject of the sewage outfall up to quite recently have, I think, led to a pretty general belief that an outfall at the Prongs (to the east and further south of Colaba Light House) would be attended with no risk of pollution to the harbour; but its immense cost is almost prohibitive. It is difficult to doubt that if by the force of circumstances the Lovegrove outfall had not been pitched upon, following the course of the 'Nullah' which originally drained the town (or very nearly following it), the outfall scientifically approved and decided on would have been on the east probably near the old light house at Colaba, till it was driven to the Prongs by general clamour." In fact, a study of the whole question of this outfall clearly shows that *the Colaba outfall has been considered by some of the most competent Engineers to be the best for the city.* But the Government, however, oblivious of the city's best interests, wrote to say, "They could never consent to receive the sewage in the immediate foreshore of the new Military Cantonment at Colaba, and the proposed outfall is therefore inadmissible." In this connection the Municipal Corporation of Bombay, in their reply quite recently forwarded to Government, regarding proposals for the development of Bombay city, also say: "There is no doubt that the city has suffered considerably by the imposition of the Worli outfall on the Western side of the Island through the instrumentality of what was known as Dr. Hunter's Drainage Commission, appointed by Government during the administration of Sir Richard Temple. The city was agitated and alarmed beyond measure when the proposal was first mooted by the Commission, and endeavours were then made to allay their fears by hasty and erroneous float experiments by means of which it was endeavoured to prove that the sewage would be certainly carried away to the open sea. The city, however, was never reconciled to a location of the outfall so manifestly unnatural and altogether repugnant to its physical configuration, and the Corporation made strenuous efforts from time to time to have what they held to be a blunder remedied. The Corporation would draw the attention of Government to the reports of Mr. Baldwin Latham and Mr. Santo Crimp, both Sanitary Engineers of the highest eminence, whom they engaged at considerable expense to come out to Bombay to report upon some of the most urgent sanitary matters affecting the city. In October 1892 the Corporation made a last effort in this behalf. With Mr. Doig's valuable report on the working of the Shone System as applied to Rangoon, and which was

to be applied to Colaba, they again appealed to Government to reconsider their decision not to allow any sewage outfall at Colaba. But Government were not to be moved from their determination on this subject, and the appeal of the Corporation was rejected. Thus the areas between Mahalaxmi and Worli, which are beautifully situated and receive the full benefit of the sea breezes, have been rendered unsuitable for residential development, and the natural expansion of the city in this direction has been greatly retarded."

What we have said above, regarding our present sewage system, is more than enough to shew the very faulty lines on which it has been, by force of cicumstances, conceived and worked up to now. With an admittedly faulty outfall, so potent for evil by fouling the city's best foreshore, and so seriously blocking the natural expansion of the city in that most healthy direction, with a pumping power now admitted as quite inadequate to cope with the constant surcharging, with such a regrettable state of things in our sewers and storm-water drains admitted out of the mouth of our own officers, and with some of them cleaned only once in a year or two, or even five, while some have not been cleaned for the last sixteen or seventeen years, or not at all, owing to their manholes losing themselves in official oblivion and not found on the Municipal charts in consequence, and, to crown all, with the silt diminishing the calibre of some of the sewers by fully 25 per cent., and so solidified, or rather petrified in some places, as to defy its removal even with a pick-axe, it is not difficult to imagine the disastrous results to the health of the city from such a sewerage system, " Scientifically worked," as it has been, almost with a vengeance !

In thus pointedly drawing attention to the many serious defects of our sewage system, we need hardly say, we have not the slightest wish to cast the blame wholly or solely on the shoulders of the officers of the Municipality. There were of course many factors in it which could not possibly have been anticipated, and many others which were wholly and solely introduced by the peculiar habits of the people, and over which they have had no control. But it must be confessed, that, even after making all reasonable allowances, the actual results represent the sum total of the many sins of commission and omission of the different Municipal Administrations in each succeeding year, and that it cannot be entirely lifted off the shoulders of those who ought to have been and were really responsible for the efficient working of our drainage system. In this connection it must also be said in justice to the Bombay Municipal Corporation, that they have, as a rule, been willing to carefully consider and sanction any necessary works of expenditure suggested by their Engineering advisers, and even remedy some of the evils on the independent suggestion of some of their own members. But the remedies have often been considerably delayed in their tediously halting and dilatory passage through pedagogic or sleepy Committees, and, by this process of slow transition, have not always come up to expectations. Meanwhile public health has suffered seriously.

We will now indicate in a general way the directions in which and the *measures by which some of these defects in our present sewerage system might be remedied or minimised* as much as possible. We have already sufficiently shewn, by some of our executive officers' own reports, as well as those of the special expert advisers of the Corporation, that our present system of sewerage, although based upon the most approved and correct water carriage principles, is yet incomplete, imperfect, insanitary and not properly worked.

Mr. Baldwin Latham in his book on the Sanitation of Bombay regards the system as incomplete, and says : " In Bombay the authorities have rightly considered works of sewerage necessary to secure health and comfort of the people, and have inaugurated a system of sewers, but unfortunately the system is not complete, and what has been done is so misused as in my judgment to seriously threaten the health of the people. The sewers of Bombay, instead of being put to their legitimate use, have been converted into underground receptacles of decomposing filth, and instead of flowing with an ever moving and living stream, are silted up with decaying matters, giving off deadly gases to the positive injury of the health of the people." It is also *incomplete* in another sense, and that is that it fulfils only very partially one of the essential purposes for which the water carriage system is designed and used in most civilised cities of the world. That purpose is the removal of the night-soil directly and rapidly from the houses into the drains and sewers. Unfortunately for our city, however, for want of a better alternative, that most disgusting intermediate *system of hand removal by the Halalkhore* has been adopted. As a consequence, the night-soil requires to be first removed by these men in baskets from the houses to the *Pail Depôts*, almost all of which latter are located in the most crowded centres of the city. From these depôts the night-soil is emptied in bulk at certain periods of the day into the sea. There are more than two dozen such Pail Depôts, and into these are discharged the excreta of the whole city, practically, within a comparatively short space of time, every morning and evening. The sewers at these points are naturally surcharged, and the contents necessarily stagnate and decompose in them rapidly in our warm climate. These Pail Depôts, therefore, cannot but prove a source of considerable nuisance and ill health in the localities in which they are situated, and must be condemned. Their existence, however, has to be tolerated *nolens volens* because, as the system is worked at present, there is no other alternative. The chief reason for the continuance of this Halalkhore system is that, in a very large number of houses, the system of privies built on the water carriage principles is not yet adopted, and the house connections not yet completed. *It would be very desirable if the Municipality enforced the water closet system on all the house owners, as far as practicable, provided the executive authorities have made adequate provision for a sufficient and constant water supply for*

flushing purposes. Without this water supply, the compulsory enforcement of the water closets would be simply disastrous to the city, unless some sort of an intermediate water closet, on the lines suggested by our present Health Officer, in his letter to the Commissioner, dated 20th December 1906, is generally adopted, if it is found to work satisfactorily. This scheme has been sanctioned by the Sewerage Committee of the Corporation to be tried provisionally, and experiments have been made by the Health Officer and Executive Engineer. But, as far as we are aware, it has not given the satisfaction that was anticipated, although no definite report has as yet been finally submitted to the Committee.

The system is also *incomplete* because large areas of houses, and in fact whole districts to the north of the city have no drains or sewers built for them. It is somewhat strange to find that even such fashionable localities as the Khamballa and Malabar Hill districts are only just beginning to be provided with a *sectional sewerage system worked on the Shone system of Ejectors, and by the Biological process,* with its effluent discharging into the sea opposite Mahalaxmi.

For the water carriage system of sewerage to be successful in our city, *it is necessary that all the districts should be drained and sewered as quickly as possible. The house connections and water closets should also be pushed with much greater rapidity than at present,* so as to supply the much needed sufficiency of volume to the contents of the sewers to give the necessary pressure and velocity to the present almost snail-like and sluggish current flowing within them. For want of enough pressure and head, *i.e.*, the height of the contents, as well as for want of enough pumping power at Love Grove, there is a *constant silting and accumulation*, and *consequent surcharging in our sewers*, and this gives rise to endless complaints from the people of Bombay. Until this increased rapidity and increased pumping power are attained, there is apparently no immediate remedy for such a state of things. It must be admitted that the Corporation are slowly progressing in this direction. It cannot also be denied that slowness and caution in the adoption of any new measures, of which we know nothing practically, is very desirable. But it must also be admitted that they are not pushing the necessary works fast enough, as the necessities of the case would seem to demand. In this connection the following remarks of a very able former Municipal Commissioner, Mr. H. A. Acworth, are worth quoting from his highly interesting and authoritative "History of the Drainage and Sewerage of Bombay." He says, "It is no justifiable excuse for delay to make to citizens who are being poisoned in the air they breathe and the ground they live on by festering pools of sewage which there are no means of carrying off, that it is difficult to decide between this or the other system. The Corporation exist, they are elected and appointed to decide such questions, and ought to be ready to move before they are forced to move, as forced they must be in the end. There is doubtless a good deal of money to be spent, but this cannot be avoided in any case." With our experience of the workings of our Municipality in the past, however, we are afraid the necessary works will drag along their slow length, perhaps for another decade or two yet. And, in the meanwhile, notwithstanding that they pay the full Municipal rates and taxes for proper sewerage and conservancy, people have to suffer not only from a variety of intolerable nuisances, but from a serious and positive danger to their health and their lives. They have, therefore, the right to demand that something shall be done, in the meanwhile, to give them at least some measure of relief. And, with that object, it is necessary to sufficiently strengthen the present number of halalkhores until such time as a constant supply of water for flushing purposes is obtainable, the house connections are completed, and the water closet system generally adopted. This, of course, will be a provisional measure only, and may be dispensed with at any moment. In this connection, the Health Officer very disappointedly says in his letter already alluded to, "It has been decided by the Corporation that no more pail depôts be provided, but that 500 more halalkhores should be provided instead. But up to the present time this has not been done. The complaints of flushing gullies and the pouring of night-soil into gullies still continue to be made. The halalkhore's work is hard and repulsive, and it is only to be expected that he will shorten his trips, if not supervised at every turn, and that is impossible." It is not at all his fault that the complaints should continue. He has been very energetic in his advocacy of various reforms in our city's conservancy, and has zealously put forward various measures and suggestions before the Corporation, from time to time, for their careful consideration. But various circumstances have combined to obstruct their adoption, for which he certainly cannot be blamed. Under the circumstances, he calculates that in all 5,488 halalkhores would be necessary to satisfactorily meet the sanitary requirements of the city. The present establishment of these men is about 2,300. About 3,000 more are, therefore, still needed, and these extra men would cost about four and a quarter lacs of rupees more every year to maintain. For this and for various other considerations, æsthetic, administrative, and economical, he is naturally very strongly opposed to their continuance, and very rightly too. But, as matters stand, there is for the time being no other alternative but to make a reasonable increase in their number. For the interests of the general health of the city are imperative, demand careful consideration, and must be met to a reasonable extent.

The *sewerage system* besides being incomplete, is *also imperfect and insanitary* This we have already pointed out in detail. One of the causes of its being insanitary, and which requires careful consideration and correction, is the *dangerous leakage of sewage matter from a large number of the city's drains and sewers.* This leakage has been *remedied*, we believe, to a certain extent *by a "Waterproofing" of all surfaces in contact with sewage, i.e.* by an impervious coating of cement to the inside of these drains, as suggested by Mr. Santo

Crimp. But this operation of waterproofing requires an early completion, so as to make them practically watertight, and prevent the present serious contamination of almost all the wells in the city.

A proper system of ventilation of the sewers adapted to our own wants, and on the lines of the most recent advances and experiences in it, should also be considered. Various systems of ventilation have been suggested during the last 10 years. A committee of the Corporation have had under their consideration, amongst other matters relating to sewers, Messrs. Shone and Ault's "twentieth century system of sewer ventilation," the Boyle system of ventilation, etc. But we are not aware that any definite line of action has yet been decided upon, much less actual construction of any work of the kind.

Two other most important and highly insanitary factors or defects seriously hampering our sewerage system still remain to be considered, *viz.*, the *surcharging of our sewers and the faulty location of the sewerage outfall.*

With regard to the *surcharging of sewers*, the complaint regarding it, and the serious nuisance it creates, is a chronic one. It is due to the following chief causes:—

1. The *misuse to which the sewers have been put* during all these years, both *by the people and by the Municipality* themselves. The people have done so from a want of knowledge and appreciation of the most primary axioms of sanitation, and by their peculiar habits, handed down from generation to generation, of washing their household utensils with road detritus and ashes, and of throwing all waste or useless materials not wanted in the house into the drains, house gullies, privies, etc. But the Municipality have contributed to this nuisance very materially also, both directly and indirectly. *Indirectly*, by not properly supervising the regular flushing of house drains, and the periodical and systematic cleaning of pipe sewers as well as the larger sewers in former years, and thus allowing the silt to accumulate and harden almost into a stony consistence in some of them, and also by not providing sufficient pumping power at the Love Grove outfall, long ago. *Directly*, by allowing the night-soil to be thrown in in mass daily, at certain centres or pail depôts in the city, and thus suddenly causing a strain on the carrying capacity of the slow-moving and sluggish current in the sewers, at certain hours in the day, which they are quite incapable of meeting. This must lead to stagnation and surcharging in some of them, and the consequent emanation of most offensive smells creating an unbearable nuisance in their neighbourhood, if not all over the city.

It was as far back as the year 1889, that the then Health Officer, Dr. T. S. Weir, in a report to Mr. Latham, said very pithily and caustically, "It must be recollected that the new sewer is tried as no other system in the world is tried. There is discharging daily in fœcal mass some 340 tons of night-soil in the sewers,"—it is probably nearer 600 tons now,—"and why is this done? Because the harbour outfall, the ancient way of discharge, was closed by Government, and because the interests of the city have been sacrificed to the interests of the harbour. Both Walton (the then Executive Engineer) and I objected strongly to the discharge of night-soil in mass from the Carnac Bunder night-soil depôts into the sewers." But all the good that their "strong objection" did, was what would be expected from a pair of good Samaritans crying in an official wilderness, *viz.*, to raise a vain haloo. It has been the fashion, whenever honest complaints of the intense nuisance created by this surcharging are made by the people (who are practically next door neighbours, so to say, to these foul smelling sewers), to sneeringly flaunt them back in their teeth. It is easy to say that they must quietly bear this nuisance, because it is unavoidable, or that they must thank themselves for it, because it is of their own creation. But the Municipal Authorities conveniently forget that theirs is no inconsiderable share in contributing towards this nuisance as we have shewn above.

(2) But there is yet another factor largely responsible for this silting and surcharging. And that is the accumulation from *washing down into the sewers*, especially during the monsoon, through the old storm-water drains connected with them, *of large quantities of road detritus and other foreign substances* which are daily swept into the latter from the road sides. Mr. Acworth's remarks on this subject are very apposite and suggestive. He says, in his History of Sewerage, "I am afraid, however, that, until some method has been devised for intercepting the silt which so largely enters into Bombay sewage, there must be a heavy annual bill of repairs (of the Pumping Engines at Love Grove). It must be remembered that there are two main causes for it. One is the large use of sand and grit by the people for cleaning metal pots and pans. This, unless intercepted at the house, must enter the sewer, however complete the separation of sewers from storm-water drains. But the other, and I suspect the chief cause, is the contributions of road detritus and other extraneous matters which the sewers receive from the old drains with which they are everywhere connected during the dry weather, and very largely connected even during the rains. These old drains, besides conveying storm-waters in addition to sewage, are open and unprotected at numberless points to receive, and do receive, every imaginable sweeping from the surfaces of the street. Though theoretically they are disconnected from the new sewers during the rains, yet in practice they remain connected with them as long as the capacity of the latter is adequate to receive their contents, it being deemed a lesser evil to let the new sewers carry what they were never intended for, than to let sewage be carried into the sea by the outfalls from the old drains while it can possibly be avoided. And thus, altogether indepen-

dently of the grit and sand from the *nahni* and back yard, we have an immense contribution of silt partly concreting in the beds of sewers and checking their flow, and partly pouring down to the pumps at Love Grove to damage them and cause expense. Of course the remedy for this is the absolute and perpetual severance of all the old drains and all channels for storm-water from the new sewerage system, and this can only be accomplished when the latter is complete." It is scarcely possible to hope, however, that they will be completed for another decade or two yet, if progress is to be made in the leisurely manner in which it has been made hitherto.

(3) The third and perhaps the most important cause of this surcharging is the *want of sufficient pumping power at Love Grove.* Mr. Baldwin Latham, the sanitary expert, gave it as his opinion that "it would pay the Municipality to give the engines away, and purchase new engines and pumps of a more modern pattern." And new machinery has had to be sanctioned in the end, after years of weary waiting, in this very year of grace 1908. But it is still considered doubtful by many whether this has been a correct step, and in the right direction, and whether, instead of sanctioning this fresh expenditure to the extent of nearly a million rupees, the question of the final location of the outfall should not have been first settled, and the final indent for the fresh pumping machinery should not have been subordinated to and influenced by this decision. Our present Health Officer, for instance, seems to be of this opinion. In a recent letter to the Municipal Commissioner on the subject of the future expansion of Bombay, he says, "But would it not be wiser to pause and consider whether the outfall at Deonar is not the proper one, before drawing up any scheme for the extension of the city, and before embarking on an outlay of Rs. 10,00,000 on new pumps which will not deal with the whole Island. The direction of the new sewers in the north of the Island is surely away from the centre of the city, rather than towards it." Mr. Baldwin Latham also urged, in his report already mentioned, that the question of the final outfall should be first decided. He says, "I strongly advise that at present nothing should be done towards making any further extensions of the sewers until the most important matter, the question of the outfall, has been decided." Messrs. Taylor and Strachan, however, the former of whom was specially invited to advise the Corporation on the subject of this surcharging, have recommended certain measures, in which a new installation of four more pumping engines of the vertical pattern has been included. The recommendations of these eminent sanitary Engineers are briefly :—

"(*a*) The erection of 4 vertical pumping engines specially designed for working at varying speeds and heights with a maximum discharge of about 60 million gallons a day.

(*b*) The construction of a detritus chamber with dredgers and screens.

(*c*) The construction of a special overflow weir and channel to the existing Worthington pumps.

(*d*) The construction of an additional high level discharge main from the Worthington pumps.

(*e*) The consideration of the construction of a low level outfall delivery, from the new machinery to existing point of discharge into the sea.

(*f*) The construction of an ejector chamber at the lower end of the Queen's Road sewer, to pump the sewage into the main outfall sewer at Kamatipura Falkland Road Crossing.

(*g*) The reconstruction of the sewer from Shaik Memon Street to Carnac Road Railway Crossing at a higher level.

(*h*) The reconstruction of the sewer from the Town Hall to Carnac Road at a higher level, with the possible addition of an ejector station for the Fort district."

They, as well as our own Municipal Engineers, agree in thinking that an adequate pumping power from a lower level than at present would prevent this surcharging of sewers in the future. But Messrs. Taylor and Strachan condemn the existing Worthington Horizontal Pumps, as their conversion into vertical pumps would be costly and difficult. They recommend an entirely new installation as mentioned above. Our Municipal Engineers, however, think it most desirable to make the best use of the existing pumps by their conversion into indirect acting vertical pumps. This, in their opinion, would be very much more economical and work well, and the saving in cost would be about Rs. 2,75,000. The Corporation have, however, as already stated, following the advice of the experts, finally sanctioned, only a few months ago, the purchase of an entirely new installation.

The Consulting Engineers have, besides the above installation, made another important recommendation for the early consideration of the Corporation, *viz.*, the provision of a low level outfall, so as to admit of the sewage being raised only to such height as is necessitated by the level of the sea at different hours of the day. The cost of this, as well as of the other works recommended by them, is estimated at about Rs. 20 lakhs. The Municipal Engineers are strongly opposed to this heavy expenditure, and recommend another and a much cheaper scheme instead, which they say would cost only about 5 lakhs. Again, the Consulting Engineers believe that the provision of a free outfall at Love Grove and a sufficient pumping power would not only prevent surcharging, but also remove silt. The Municipal Engineers do not agree with this opinion in its entirety. They consider that the present pumping power is sufficient, if only the pumps were made efficient by certain suggested alterations in them. Yet they also consider a free outfall most necessary and desirable. The Executive and the Special Drainage Engineer also

differ amongst themselves in some important particulars. The question of the further works proposed by Mr. Taylor is therefore still pending final settlement. When that is coming, however, no one can prophesy.

It must at once be freely admitted here, without any reservation, that it is very difficult for a body like the Corporation to decide such questions quickly, because they involve many side issues and present some very technical points for consideration difficult to grasp easily, and because, like the proverbial doctors' opinions, *all* professional opinions, not barring the lawyers' and the engineers', differ very often and very much on various points. Also because, owing to this bewildering diversity of opinions, their discussion is greatly unsteadied and retarded, and because there is the fear, constantly present before the minds of the members, that any particular scheme, finally sanctioned and carried out, may not after all be the proper one suited to our local conditions and wants, and the expenditure may have been practically wasted. But after fully realising their difficulties and their responsibilities, we may be pardoned for saying that large and important problems of sanitation affecting the health of a large population cannot afford to wait for years and years, and that they must be decided within a reasonable limit of time. The Corporation, no doubt, have been active and unceasing in their efforts to obtain all available information from time to time, in the shape of numerous reports from their own officers, as well as special reports from various consulting engineers. But no impartial observer can help saying that, when received, many of them have been "considered" and "reconsidered" very leisurely indeed, without, in the end, coming to any definite action in many instances. And in the meanwhile the health of the city must suffer considerably, because, in order to avoid unnecessary extra expenditure, no practical means of temporary but immediate relief have been adopted, in the very distant hope that the larger works recommended by the engineers, the health officer, and the expert advisers would soon be sanctioned and completed. But as we have pointed out already, it has been a weary waiting in many instances, and the relief which has at last come has been almost always very long in coming to a long suffering people.

Sewerage Outfall.—Coming to the question of the city's Sewerage Outfall, a great deal of acrimonious discussion has centred round this vexed subject. Opinions have differed a great deal, according as they have been inspired by official influence and direction, or given by impartial experts specially invited to an independent consideration of its present location. Except Sir Robert Rawlinson and Major Tulloch, almost all expert opinions agree in thinking that the location of the outfall to the west of the island, in its present position at Love Grove and Worli, was a grave mistake. But even Sir Robert Rawlinson and Major Tulloch were strongly *opposed to a marine outfall on the west.* They recommended an outfall of the sewers in the direction of the natural fall of the island, which was towards the north and north-west, so as to avoid a marine outfall, which was not permissible in any other direction without creating serious nuisance. Hence it was that Major Tulloch was forced to recommend it in this the only direction left to him (as pointed out in his report on "A Project for the Drainage in Bombay"), for these two very good reasons, *viz.*, (1) that the natural slope of the island was towards the north and west, and (2) that any discharge on the east or south would be likely to foul the harbour in those directions and create the same nuisances which are now complained of on the west. This location of the outfall to the north-west of the island, however, is now a "Settled Fact," which it is too late to disturb for various considerations. All that can now be done is to minimise the evil as much as possible, and to improve existing conditions whereby the nuisances arising out of it might be effectively neutralised. With that idea various schemes have been reported on and considered by the Corporation from time to time. Major Tulloch proposed that the main sewer should be continued from Love Grove to a point near Sion, the sewage to be then lifted by pumping machinery into an open high level sewer running to the north-west of Bombay, where it was to be applied to the land, and the effluent run off into the creek north of Trombay. Besides this, there were to be four principal branch sewers in different parts of the city. With regard to this scheme of Major Tulloch's, Mr. Acworth in his "History of the Sewerage of Bombay" says, "It was reasonable to suppose in 1872, that Love Grove outfall had been finally condemned. With regard to a Colaba outfall, Government had written that they could never consent to receive the sewage in the immediate foreshore of the new Military Cantonment at Colaba and the proposed outfall is therefore inadmissible. Major Tulloch then ended by saying, 'What are we to do? The western coast is closed to us. In the west, south, and east, we cannot place an outfall. There is only one point of the compass left to us, that is the north, and that is the direction in which this project comtemplates that the sewage shall be taken.'" Messrs. Santo Crimp, Midgley Taylor, and Baldwin Latham, however, very strongly supported the southern or Colaba outfall at the Prongs. The last-named expert does not believe that there is any overwhelming objection to its construction even now, except that its enormous cost would be prohibitive. And this last is certainly an item to be reckoned with in the Municipal administration of the city. Others advocate the removal of the sewage outfall to Deonar, and by using the sectional Shone System and the existing pumps at Love Grove, to lift the sewage at different places in the unsewered districts in the north, at a lesser height into a main sewer, and then to treat it biologically in septic tanks and filter beds, and utilise the effluent on the reclaimed land by growing crops and discharging the effluent into the sea north of Trombay. This proposal is almost analogous to Major Tulloch's, except that it utilises the biological process for its disposal instead of applying it in bulk direct to the land as proposed by him, because when he reported on the subject 25 years ago septic tank methods were not known.

Our present Health Officer favours such a scheme in a letter, dated the 4th February 1908, to the Commissioner on the subject of the future development of Bombay, from which we have already quoted the above. He does not approve of the present Love Grove outfall in the centre of the island, and says, "The direction of the new sewers in the north of the island is surely away from the centre of the city, rather than towards it. The artificial height to which the sewage has to be forced by the Shone System, and afterwards to gravitate to a well before it can be lifted into the sea, is surely not sound engineering."

Mr. Santo Crimp has advised, in a special report to the Corporation, "a scheme for the extension of the outfall sewer from the point of junction with the cast-iron pipes by means of a 6′-6″ circular brick sewer to Worli Point, and to discharge there all the sewage of the city on the ebbing tide, and to discharge as now, at the Love Grove outfall, on the flowing tide only." This discharge of sewage further north and far out into the sea towards Worli would take place at a much greater depth below low water spring tides than at present. This would, in the opinion of the expert, obviate the awful nuisance on the whole western foreshore, which latter could then be safely utilised for residential purposes.

Under this conflict of opinions it would be difficult to say what would be the best scheme for the location of our sewage outfall. But the Corporation have apparently pinned their faith to the recommendations of Messrs. Midgley Taylor and Santo Crimp, and begun work on the lines suggested by them, and we can only hope they will be soon completed, and will realise expectations, to the satisfaction of all concerned.

(2) We will now briefly discuss some of the *principal defects in the removal and disposal of our Town Refuse*, and the chief measures by which they can, to a certain extent, be remedied. To facilitate discussion, our local conservancy service may be best divided into—

1. Sewage removal, *i.e.*, removal of all liquid and semi-solid excrementitious and polluted sewage and sullage matter, capable of being removed by drains and sewers.
2. The collection and removal of household, street, and garden refuse, and refuse from horse and bullock stables and cowsheds, etc.
3. The removal of night-soil by the basket or the halalkhore system.

(1) To the first, besides its legitimate obligations of removing human excrement, sullage water, and washings from *nahanies*, privies, and bathrooms, other materials quite foreign to it are added, such as refuse and food remnants of cook-rooms, sand and ashes, pieces of vegetable matter, rags, small stones, and tinpots, and even dung from milch stables. This portion of the subject we have already discussed.

Coming to Nos. (2) and (3), it is our honest belief, which is an echo only of the strong conviction of most of the permanent residents of this city, that the conservancy of the city has been carried on for a long number of years past, and, with all due apologies to the Municipal Corporation and to our present energetic Health Officer, even now, with an inadequate minor staff and insufficient appliances, and that our conservancy service is not what it should be. This is a matter not only of everyday experience and observation of those interested in the public sanitation of the city, but can also be readily proved from some of the very reports of the Health Officers of the city, past and present. *More than 500 sites for dust bin stands exist* in various parts of the city, on some of which there are placed even 2 or 3 carts. And *yet the number is found insufficient* to meet the ever-increasing requirements of the city. It is a matter of common observation, that on many of these stands the carts remain not only loaded to the brim, but actually overflowing all round with heaps of stinking garbage, road refuse and stable litter, in close vicinity to dwelling houses for hours together. In a recent article in the *Times of India*, ironically headed "Bombay the Beautiful," all that we have said above has not only been endorsed, but graphically demonstrated in a vivid photographic picture of a group of 3 such carts located next the precincts of our *Alma Mater*, *i.e.*, in the close vicinity of the University Gardens, which has been reproduced in a recent number of that journal. It was, however, not a little amusing to observe the magic effect of this promiscuous publication. For within a fortnight or so of this telling illustration of our Municipal sanitation, in the shape of this hygienic anthology, all the 3 carts had somehow suddenly disappeared into space, never more to return.

Besides these dust-bin carts, the number of scavenging, drain, cesspool, and night-soil carts, is also found insufficient. According to a very useful and suggestive report on the Conservancy system of the city, submitted by the present Health Officer, in December 1902, the city's conservancy alone, excluding markets, hospitals, etc., cost something like 17 lacs and thirty-five thousand rupees, of which about 7 lacs and seventy-nine thousand rupees were recovered from the Halalkhore tax. And yet, in spite of this very large expenditure, even the present energetic Health Officer has had to confess in the report already alluded to, that "to say that the system is satisfactory is very misleading, but that with the material to work with, and the method employed, no one will deny that the city is well swept. Although the number of carts and persons employed is so enormous, the removal of refuse and scavenging is not carried out with that regard to efficiency, rapidity, or economy which should obtain in a properly organised system of a large city." Further on he remarks, "the question asked by the Corporation is, 'Is the number of carts, etc., sufficient? and if not, how many more are required?' The answer given by the Divisional Health Officers, who are completely in touch with the Conservancy system of the city, is 'No.' The material at their disposal for completely removing all the refuse, etc., is not sufficient, and for the following reasons."

After enumerating these, he remarks, "If the method of removing the refuse and night-soil, etc., is to remain the same, then I fully endorse their opinion ; but I do not consider the system satisfactory, and would advise the Corporation to immediately consider the advisability of improving it." True indeed! We all also fully endorse this authoritative opinion. But a somewhat queer and rather uncomfortable fact comes out of it rather unexpectedly. It is now more than seven years since this opinion was given, and yet, strange to say, beyond the talking stage, the old order of things has not changed one whit, and the uncouth old system continues exactly as it was then. Should we not then, in the meanwhile, have done something in these six long years to mitigate the evil and the danger of the old system, until the latter had ultimately yielded place to a better one? And yet the figures supplied to us from time to time show that scarcely any appreciable increase in men or material has been attempted. In the year of the report, 1901, the number of scavenging carts, bullocks, and persons employed were 1,833, 2,493, and 7,390, respectively. Notwithstanding the very large increase in the population since then, these numbers have not materially changed. In a letter of the Municipal Commissioner, dated 14th April 1908, regarding the permanent reorganisation of the minor staff of the Health Department, the number of carts is given at 1,883, the same as in 1901, of bullocks at 3,126, or 633 more, and of the minor staff at 7,494, or only 190 more than in 1901. If, then, the Health Officer in his report of 1901 has had to confess and endorse, that "the removal of refuse and scavenging is not carried out with efficiency, rapidity and economy because the material at their disposal for completely removing it is not sufficient," then, the material at their disposal being about the same, it surely cannot be considered efficient at the present day, in view of an increase over the population of 1901 by more than 2 lacs of people. And the city must necessarily suffer, in consequence, for want of sufficient men and materials, in its general health and sanitation.

(3) Coming to the barbarous and most filthy system of removal of the night-soil by the "halalkhores," *i.e.*, by night soil removers by means of the basket, it is a matter of common knowledge that the present number of these night-soil removers is not adequate to cope with the efficient and expeditious removal of the very large quantities of night-soil of the different districts to their respective depôts. It has been shown to be a physical impossibility to expect them to honestly carry out their work, on account of the great distances to travel and the limited time in which to do it. Hence it is but natural many of these men should lighten their work considerably by quietly emptying their loads of filth into the nearest drains. The effect on the health of the people by this wholesale and abominable pollution of the soil on which they live and breathe, may be easily imagined. The dangerous part which such an imperfect system of conservancy and night-soil removal plays, needs no further criticism.

In fairness to the present Executive Health Officer and his staff, it must be freely and frankly admitted that the city has improved materially as regards its general conservancy, which of course means greater cleanliness than in former years. In justice to the Health Department it must also be admitted that the city's uncleanliness depends in a large measure on certain peculiar insanitary and dirty habits and customs of the poorer classes. Besides these, there are various other factors, contributing to this insanitary state of things, for which the Health Department can in no way be held responsible, as these have been, and are still, beyond their control. It is true that continued efforts have been made to remove these nuisances and evils as much as possible. But in spite of them, even the Health Officer himself cannot deny that the city, as it stands at the present day, is certainly not what it could and should be, that there is a great deal of truth in the complaints made, and that there is considerable room for improvement in various directions.

Coming now to a consideration of the *measures for improvement in* our present obsolete *methods of conservancy*, it will be at once apparent that the expeditious collection and removal of the city's refuse, and the proper disposal of the night-soil, constitute another most important and urgent factor in the general sanitation of the city, and that it presents some special features which require careful consideration and early improvement.

(1) Taking the latter, *i.e.*, the *proper disposal of the night-soil*—first, various methods and principles for its removal have been suggested ; amongst the latest and the best being the Hydraulic System of Mr. Baldwin Latham, and the *Shone* and the *Liernur Pneumatic Systems*. But many of them are not easily applicable or adaptable to our city, and almost all of them cannot approach the comparatively superior merits of the water carriage system. The *Shone Pneumatic System* working by air ejectors has, however, proved to have worked well in several towns in which it has been adopted, and the Bombay Municipality have, therefore, going against the strong condemnation of it by Mr. Baldwin Latham, finally adopted it in the sectional drainage of certain districts, and it has been already fully working for some time past at Colaba. But the problem of the disposal of the larger portion of the city's night-soil can only be properly solved in our city, as elsewhere, by the thorough adoption of the most sanitary and expeditious method known at the present day, *viz.*, *the Water Carriage System*—and this has already been adopted in the greater part of our city. For its (the water carriage system's) proper working and success, however, it is very essential that almost all the houses in the various districts of the city, except such small tenements and huts as cannot possibly be made to do so, should be connected with the sewers by means of water-closets as expeditiously as possible, provided the water supply is also improved side by side.

There would be one great relief immediately apparent if the privies of all the houses in the city were thus connected up. And that would be the abolition of the present

abominable system of basket removal of the night-soil by the Halalkhore, and of all the attendant nuisances and evils in its wake. Another practical advantage would be a very considerable decrease in the very heavy item of annually recurring and steadily increasing expenditure on this basket removal system, which at present amounts to nearly 3¼ lacs of rupees. There would also be an end to the difficulty of finding sufficient accommodation, even at greatly enhanced rent, for the large body of men employed, or the difficulty of providing them with specially built sanitary chawls at great Municipal expense, as an alternative. It would also do away with the trouble of controlling and replacing them when on strike. Further, the large number of night-soil depôts, at present serving as so many intolerable nuisances in certain parts of the city, would also go their way with the Halalkhores, and allow the people of those localities to breathe in a little more pure air, than at present, with a grateful sigh of relief. The recommendations of the present Health Officer in this connection are hence well worth serious consideration. He has put the advantages and objections to the Water Carriage System so clearly and pithily that we will quote them here in his own words :—

"*Recommendations*—

1. That no new house be allowed to adopt the privy basket system.
2. That, where possible, all the houses be put on the Water Carriage System.
3. That where it is impossible to provide Water Carriage, the receptacle to be water-tight.
4. The builder of the house to have the option of a water-closet, or a shaft discharging on to a receiver connected with the sewer. A modern water-closet need not be insisted on but the intermediate system should be the alternative.

Advantages—

(*a*) The night-soil will be removed at once without hand labour.

(*b*) The night-soil will not be carried through the streets.

(*c*) The gullies will not be always damp and will not stink. The soil and air will not be polluted, and the air in the gullies will then be of value to health instead of the cause of disease.

(*d*) The expense of providing Halalkhores and Depôts will be avoided, and there will be a diminished annual expenditure.

(*e*) The soil will not be polluted with sullage water.

(*f*) All the waste water could be used for flushing.

(*g*) One Halalkhore will be able to flush or clean as many privies as are now done by a dozen.

Objections—

(i) Initial expense to landlords, *viz.*, cost of converting old privy to water system. This will be small and more than counterbalanced by the reduction of the Halalkhore tax and the improvement in his property.

(ii) *Water-pressure.*—The pressure varies in different parts of the city and cannot be relied upon to supply the top floor of every four-storied house. But in many parts of the city it is equal to 30 lbs. once in 24 hours. This is, however, no objection to the system I advocate. Great water pressure will not be required, and all the flushing, automatic or hand, will be done in the gully, in addition to which the waste water from Nahanies will be used and the ablution water in the shaft, sufficient to cleanse it.

(iii) *Blockage.*—No more than now, each receiver would be cleansed and flushed daily or oftener automatically."

The advantages are so many and so obvious, and the objections to its general introduction so few and insignificant, except one very strong one, that it hardly requires any further discussion. But that one objection, *viz.*, the present insufficiency of water-pressure, is worthy of more careful consideration from different points of view than is given to it. We are afraid the Municipal executive have thrust this real difficulty aside a little too lightly. Both the Health Officer and the Executive Engineer are of opinion that all the conditions absolutely necessary for the proper and efficient working of the Water Carriage System are obtainable at present, and they think the present intermittent, irregular, and scanty domestic supply of water "is amply sufficient to remove the night-soil by the Water Carriage System." The Health Officer in a letter to the Commissioner, dated the 24th October 1905, says : "At the present time all the waste water of the Nahani and the bathing places discharges on to the open gully drain and it has been frequently pointed out that all this water could be utilised for flushing the drain of the Water Carriage System, and no night-soil left in the privies or gullies."

Others, however, think that for the universal adoption and satisfactory working of the water-closet system in Bombay, a more constant and plentiful supply of water than is obtainable at present, or is probable in the near future, is absolutely necessary. The Deputy Executive Engineer, Drainage, Special Branch, for instance, says in his letter of 18th May 1906 : "There only remains for me to make some remarks in regard to the proposal to use the Nahani water for flushing. I am entirely opposed to this proposal, which is apparently suggested by Messrs. Marsland and Price, as I see from the original papers that the description quoted in the report is a copy of the notes forwarded by them with their design. The experience of the Drainage Department teaches us that all sorts of foreign material is passed through Nahanies, and this would be caught in the syphon of the proposed flushing-tank. Such flushing-tanks with such material poured into them could not work efficiently for long, and there would be great difficulty besides great nuisance in cleaning the tanks. But, if added to that,

the soil pipes were to be choked with a compound mixture of night-soil and kutchra, the result would be disastrous. I can see no advantage in the scheme at all. A further objection is that if one floor were unoccupied, the next floor would get no flushing for its water-closets." The Corporation, however, at the instance of their Special Committee, appointed to consider and report on the conditions and working of the drainage system of the city, sanctioned the necessary expenditure more than 2 years ago, for giving a fair trial to this modified or "*intermediate system of water carriage*" as it has been styled, and requested the Health Officer to report on their working at an early date. No final report, as far as we are aware, has as yet been finally received by the Corporation. Theoretically this system of "modified water carriage" appeared feasible. Practically it has been found to be, we are told, a failure.

As regards *the question of the rapid collection and disposal of the city's refuse*, although it has continued to exercise the minds of our successive Health Officers and Executive Engineers considerably for years past, yet, unfortunately for the city, without attaining the much desired rapidity of removal or abatement of the intolerable nuisance that continues to exist and flourish in the city even to the present day. The antiquated system of removal of the enormous daily refuse of the rapidly-expanding city, by "kutchra" carts and bullocks, has not advanced one whit, we venture to say, from what it was a quarter or perhaps half a century back. The antedeluvian model of the old pattern "kutchra" cart has not been much improved upon, and to this day it jogs along its creaking, noisy way, freely scattering its foul contents over the roads, and being dragged by a pair of half-starved languid bullocks, as it was twenty or thirty years ago. But in this the fault does not lie with the Health Department. After several reports, and many letters, on the subject of collection and removal, to the Commissioner and the Corporation, our energetic and able Health Officer, in a spirit of extreme vexation, almost of despair, says, in a letter dated 15th August 1905, "No substantial improvement in the conservancy of the city can ever be accomplished until a more speedy system of disposing of refuse is adopted. I again strongly advise that the Corporation be informed of the whole subject relating to the removal of refuse by rail from first to last, as it is a matter of vital importance, and, owing to the opposition of the Railway Company to provide railway transit, is apparently beyond the powers of the Executive to insist upon. The matter is so important to the city that failing a better system of removal of refuse by rail direct from depôts in the city, as I have so ardently advocated, we must resort to destructors in various parts of the city and districts. . . . . What I wish to specially emphasize is that the present system of dust-bin carts, and haulage through the streets by bullock carts, is one of the greatest nuisances and eyesores in the city and primitive to a degree, and which should not be tolerated in a city like Bombay." The present Health Officer has tried his best and made considerable efforts during his regime of nearly 8 years to improve this state of things. But there has been very little progress, and his efforts have not been successful in coping with the subject owing to certain difficulties put in his way by a want of sympathetic co-operation from our two railways, the G. I. P., and the B. B. & C. I., especially the former, and the Port Trust. The Health Officer proposed to provide sidings and loading platforms at Colaba, Carnac Bridge, Wadi Bandar, Byculla, Mazagaon, and Sion, for the deposit and subsequent carriage of the town sweepings from those places by rail to Mahalaxmi, by connection with the present regular "cutchra train service," and thence on to Deonar. The B. B. & C. I. were somewhat favourable to discussing the proposal to establish such sidings at Colaba and Carnac Bridge. But the Port Trust objected to leasing land for any such purpose on their property, and the G. I. P. set their face absolutely against them any where on their line, because of the nuisance they would to a certain extent create and took shelter behind the flimsy excuse of "no room" available. They even demurred to carrying the "kutchra" over their line by any but special night trains at specially enhanced rates, suggesting to the Health Officer to deal with the foul traffic otherwise than by conveyance over the rail. A long correspondence ensued, and dragged on between the Health Officer and the G. I. P. Ry. for nearly 5 years, but without any result. And the former had at last to give it up, in sheer disgust, as a hopeless job. It is to be very much regretted that bodies like the two railways and the Port Trust, which are benefitting so largely by the industry and energy of the city's population, and whose interests are so bound up with theirs, should, instead of actively co-operating in their sanitary welfare, thus selfishly and obstinately resist all progress, simply because it would inconvenience them somewhat. For the "kutchra" can only be removed quickly outside the city, either by the two local railway lines, or by a special arrangement with the new Electric Tramway service. The Tramway Company are bound, we believe, by the terms of their contract, to carry the city's refuse by special wagons on their lines. But for the scheme to be matured and sanctioned, and the rolling stock and other special plant to be ordered, will require another three to five years in the present rather dislocated and uncertain working of the Company's passenger traffic service. But after all, it seems as if the people of Bombay will still have to wait and bear their intolerable load with ungrudging resignation, till such time as the Electric Tram service is ready.

Meanwhile, however, something must be done to give relief to our long suffering city from this great nuisance. At present, the conservancy of the city is divided into wards and sections, and for each of these a certain number of scavenging carts and bullocks, drain carts, cesspool carts and cart drivers, as well as street scavengers, are allocated. The roads and streets of the city are swept by these scavengers twice a day, once between 6 and 10 a.m. and a second time between 1 and 4 p.m. But, prior to its removal, the street kutchra as well as all other kind of refuse, such as small

carcases of dead animals, stable sweepings, trade refuse, vegetable refuse, and garbage from the various markets, etc., is mostly collected and thrown, all mixed up, into those unsavoury abominations known euphemistically as "dust-bin carts." This large heap of refuse lies rotting for several hours at a time in the heat and moisture of our tropical climate, not only in the carts, but littered all round the cart-stand, till it is removed by a passing scavenging cart on its way to the Tardeo Flats, whence it is removed by rail to Deonar. Only two trips to Tardeo are possible for a pair of bullocks, and, even for this, the number of bullocks and carts is quite insufficient, as we have already seen while discussing the causes. According to the Health Officer at least 1,800 scavenging carts and 3,000 bullocks are necessary, whereas we have less than 1,200 carts and 2,500 bullocks, out of which a certain proportion of both bullocks and carts are always on the "sick list." The Health Officer himself says: "To keep the city clean under these circumstances is almost impossible." The only way in which this can be done, is either to very largely increase the present number of carts and bullocks, or to adopt a better and more expeditious method of removal. The Health Officer is not at all in favour, and very rightly too, of increasing the present number, necessitating a very large initial expenditure and a large increase in the annually recurring one, and thereby considerably delaying the introduction of a better conservancy service until such time as the extra 600 carts are built and ready for service. Besides, such large additions at great cost would naturally tend to perpetuate the present cart and bullock system on the score of economy. A better and more expeditious method of removal can be adopted if the city's refuse could be removed by means of the railways. But, as we have already said, the railways absolutely refuse to give us the necessary facilities for such removal, the Port Trust won't assist us, and the Tramway Company are not able to do it for some time to come. *The best course*, under the circumstances, appears to be, apparently, *to adopt a system of steam motor traction*, by which the city's refuse may be more frequently and much more expeditiously collected and hauled away to Tardeo and Mahalaxmi sidings than at present, until such time as the Tramway Company are able to do it for us by electric traction on their lines. From Mahalxami it may be carried on to Deonar by the existing railway, for filling in the large areas of low-lying grounds which will be available there for a number of years yet, or it may be collected at suitable places within and outside the city, where, if need be in the future, installations for burning the "kutchra" may be set up in the shape of *incinerators* or *destructors*.

In many cities in England and on the continent of Europe, as well as America, the system of collecting and removing refuse by motors has been working with great success. And although the initial capital and working expenditure for its general adoption all over the city may seem somewhat prohibitive, yet in the long run it may prove, if a little more expensive to start with, a great deal more cleanly, sanitary and expeditious than the present obsolete bullock cart system, which, to speak frankly, is really more adapted to the limited needs of a village conservancy than to a metropolitan city like Bombay.

The Health Officer has embodied his views on the subject of *haulage of refuse by motors* in a letter to the Commissioner, dated 21st April 1908, and has suggested in it a provisional scheme for the collection and disposal of refuse by means of motors and incinerators, for immediate adoption, until such time as a more complete service, working in connection with the city's Electric Tramway service, can be elaborated and organised. His idea is to have as an experimental measure a certain number of self-contained motor vehicles, say three for the present, which could be placed at conveniently situated depôts such as Colaba, Paltan Road, and the C Ward stables, into which the contents of the existing dust-bin carts could be emptied by means of the scavenging carts. The vehicles when full would then travel on to the Mahalaxmi sidings. Instead of the present large dust-bin carts, small sanitary dust-bins could be provided for houses, the contents of which could be removed by travelling carts twice daily, or oftener if necessary. For the present, he proposes an experimental motor service at Colaba, and he calculates the initial cost of the 3 motors for it at about Rs. 12,000 each. The cost per ton-mile of motor service would be about 7 annas per day, which is about 2 annas more than the present bullock cart service. But, according to the Health Officer, it could be compensated for by the advantage, that the ugly sight of strings of these kutchra carts going along in one direction would be diverted and divided up along several streets. There would also be the possibility of reducing the present number of carts and bullocks and drivers, owing to the shorter distance the carts would have to travel to the motor depôts near by, as against the rather heavy upkeep and working expenses of the motors. A properly constructed electric vehicle or cart could carry about 6 tons of dry refuse, that is to say, the contents of about 17 dust-bin carts. The wet refuse from drains could be removed by a few drain carts as hitherto. He then enters into a general discussion of details, of how the motor service can be further extended and worked in conjunction with the present electric tram service, by which, along the latter's rail tracks, the electric cars could be hauled on to the Mahalaxmi sidings, and thence the refuse could be conveyed, after being emptied into railway wagons, to Deonar.

The Health Officer is not very much inclined to the adoption of *incinerators* to burn the refuse in. But he accepts this suggestion of the Executive Engineer who very much favors their use, and has proposed that an Incinerator of the latest pattern be erected, in the first instance, at Colaba, to deal with the refuse of that locality. The Committee of the Corporation appointed to consider the question of refuse removal have, therefore, recommended to the Corporation its early erection, as also the purchase of 3 motor refuse cars. Whether this experiment

will prove a success in the long run remains to be seen, however. The total cost of the former will be about one and a-half lacs of rupees, and of the latter about Rs. 36,000 at Rs. 12,000 for each motor. The Executive Engineer has also submitted his views on this subject, somewhat at length, in his letter to the Commissioner, dated 6th April 1908, in which he criticises some of the suggestions submitted by the Health Officer, rather adversely. For instance, he considers, from the experience of some English towns, that the collection of refuse by motors is more costly than by horses. The Health Officer, however, controverts this statement on the strength of its working in about 16 different places in the United Kingdom, where the motors have been found to be more economical. Yet he admits that the working cost would be about 2 annas more per ton-mile, or an increase of about 40 per cent. on our present bullock cart service. In our humble opinion, in view of the more rapid removal and considerable abatement of the nuisance, the increased cost alone should not be a detrrrent to the adoption of the motor service.

The Executive Engineer divides the existing system of mechanical transport of refuse into two groups, one involving the use of a tractor-engine carrying no load, but simply hauling one or more loaded vehicles or trailers, which both he and the Health Officer do not think suited to the peculiar street conditions of our city, and the other consisting of self-contained vehicles in which the propelling mechanism is incorporated with the load-carrying vehicle. With regard to the first group, which is considered unsuited to our city, we respectfully venture to say that an exception might be made in favour of the *motor road transport* by means of the recently introduced "*Renard Road Transport Trains.*" This system was first tried in the year 1900, and has since rapidly grown into favour wherever it has been tried for passenger traffic, or for haulage of goods, etc. It is worked by a light petrol locomotor engine, of 80 horse-power, weighs about $3\frac{1}{4}$ tons, and is capable of conducting about 36 tons of total weight. The engine, while acting both as a steerer and tractor to a certain extent, also transmits power to the middle pair of wheels of each of the three or four cars trailing behind it. The front and back wheels of the passenger cars and trucks are also provided with independent steering gear. Each of these goods cars weighs about $3\frac{1}{4}$ tons, can carry a 5-ton load, are able to propel themselves, and are not merely hauled by the aid of the engine as in other systems of trailers. They are also capable of steering themselves in an exact line of the road track with the petrol locomotor, without deviating in the slightest degree from its lead, or getting out of line with it by even a quarter of an inch while negotiating any sudden turn, or even tho sharpest curves on the road. Another advantage is that the weight of the engine and trucks, as well as of the load inside them, is evenly divided on all the wheels, so that heavy weights could be carried easily, without any damage whatever to the roads or bridges over which they travel. An experimental trial of the working of one of these Renard Road trains was taken in the streets of Bombay one afternoon, early in December last, by the Committee of the Corporation appointed to consider the question of the refuse removal of the city, and every one of the members present during the drive through the town, was highly pleased and very well satisfied with the smooth working of the train. The train consisted of a locomotor, a passenger car, in which the members of the Committee were seated, and two other empty goods vehicles following the latter. The drive lasted for over an hour and a quarter, and included some of the narrowest and most crowded streets in the city, as well as one or two difficult uphill and downhill roads, such as the newly opened Hughes Road and Pedder Road, and there were some very sharp curves and turns included in the runs. And yet, from start to finish, there was not the slightest hitch or accident anywhere, either to the vehicles of the train or to the large passenger and vehicular traffic in the crowded streets. The train went at a moderate but steady speed, although it could be easily regulated at 8 different speeds, from 6 to 20 miles an hour if necessary, without any breakdown, and in a perfectly straight or curved line. Notwithstanding its great length of about 24 yards, the vehicles followed like a snake, the lead of the front locomotor, without in the least inconveniencing or hindering the vehicular traffic or pedestrians on the roads, or frightening even a single horse. It never halted, except once for a short stoppage at Mahaluxmi, when the members were given an opportunity to examine for themselves and get an explanation of the working gear and the mechanism of the train, and when an exhibition was given of the very narrow curves and circles in which the train can move with the greatest ease, and without being at all upset, or falling out of the line of the leading locomotor. The only thing, perhaps, with which the Committee could find fault was the great noise which the train made while in locomotion, and which interfered considerably with ordinary conversation. But the noise is said to be more noticeable within the car than outside of it, on the road, and it could be greatly obviated by proper rubber tyres to the wheels, which would, of course, add somewhat to the cost. But with all its other advantages, the Renard train with some structural modifications, is, we believe, admirably adapted for the rapid transport of refuse. And the Committee found this first trial so very satisfactory, that they have resolved to re-consider their recommendation to sanction an order for the three motors for refuse removal, as asked by the Health Officer, with a view to the adoption, *if possible*, of the Renard Road Transport Train instead. The cost of such a road train, consisting of a motor engine and 3 trucks, would be about Rs. 48,000, each truck probably carrying about 4 to 5 tons of refuse. The initial cost would thus seem to be somewhat more. But the actual working expenses and repairs would be, it is said, considerably less, owing to the very frugal petrol consumption, and only one driver being needed for a train of from 3 to 6 trucks, and the cars necessitating fewer repairs. If further trials by our Municipal Engineers, and the Health Officer fulfil these expectations, which are yet problematical and uncertain, the

Renard train would be found to be perhaps the one system most suited to our immediate wants.

With regard to the second group of self-contained vehicles, according to the Executive Engineer, the initial cost, the working expenses, and the wear and tear of the machinery and repairs, would certainly be heavy, and its obstruction to traffic in narrow streets would also prevent its being used for a house to house collection of refuse, as much time would be lost in securing the necessary load. Either a larger number of dust bins would have to be placed, therefore, at the sides of houses or of the streets, to be emptied, or removed bodily on to the motor vehicle, and transported to the Mahalaxmi sidings, and there emptied into railway wagons. Or the contents of the dust bin carts could be emptied into the motor vehicles at conveniently located Refuse Depôts to which they could in the first instance be carried by a bullock service, and the vehicles when full carried on to Mahalaxmi sidings.

We are afraid, however, that even the adoption of the motors will not very much obviate the present dust bin cart nuisance, *unless some kind of method of a house to house removal, or a street collection of refuse is devised in connection with this motor service.* By it the refuse may be frequently removed, say four or five times a day, from the house dust bins, or dust bins at street corners, without being allowed to lie for a considerable length of time in the dust bin carts, as at present. The Renard Road train in a modified form would perhaps meet the situation admirably, we think, in this second group. With further experience and knowledge gained with regard to its working in the narrower streets of Bombay, and with only one or two refuse trucks attached, the Renard train might, in time, be also made to work as a refuse remover from house to house, and this operation could be greatly facilitated by having some sort of an easily worked hoisting arrangement attached to it, by which the small or large dust bin carts placed near houses or at the end of streets, might be hauled up bodily, and carried to Mahalaxmi direct, to be emptied there, at the sidings, into the railway wagons for Deonar.

With regard to the *Incinerators* or *Destructors*, an installation, known as Garlick's Incinerator, was fixed in one of the districts in Bombay some years ago, at considerable expense. But it was found to be useless for the purpose for which it was intended, and was finally abandoned. There has been a considerable improvement, however, since then, and destructors can now be found in the market, which can burn any kind of refuse, even of the wettest kind. There are many good types of incinerators, and, according to the Executive Engineer, "probably the best policy will be to obtain designs and tenders for a block of cells capable of dealing with 40 tons per day from Messrs. Horsefall, and Messrs. Meldrums, or on Beamen and Doas' system, and have the two erected at Colaba. Then, after at least one season's experience, the question of the general adoption of the system can be considered. The cost of such an installation capable of dealing with 80 tons per day will be about Rs. 1,40,000 exclusive of the site." And the Committee of the Corporation on refuse removal have, as we have already said, resolved to recommend the sanction of such an installation at Colaba, to the Corporation.

But whatever is done will, it is to be hoped, be done quickly and efficiently, so that the long suffering people may be relieved of this long standing dust bin cart nuisance as soon as possible.

DISCUSSION.

Dr. N. H. E. Sukhia (Bombay) said he had heard very carefully the lengthy paper read out by Dr. Master. The various points touched on by the authors were very interesting, but they had missed one point. From what they had written it would appear that the Bombay Municipality had not done everything it should have done, but the authors forgot that "Rome was not built in a day." The Corporation had been trying to do their best to meet all the demands of the executive and of the people ; not only that, but it had acted more liberally than the funds at its disposal justified. The annual income of the Bombay Corporation amounted to about a crore of rupees out of which they had set aside about 40 lakhs of rupees as sinking funds on large loans to the extent of about five crores of rupees raised from time to time. Out of the remaining sixty lakhs of rupees 20 lakhs (or more than $\frac{1}{3}$) were spent on the working of the Health Department. There were various other matters of equal if not greater importance which the Bombay Municipality had to look to. They pertained to roads, buildings, drains, sewers, &c. It was easy to say "do this" and "do that" but it would be very difficult to bring into effect all the matters the authors aimed at. It was wise for the Municipality to cut its coat according to its cloth otherwise there would be the danger of its becoming bankrupt and such a result would be disastrous to the city. Already the incidence of taxation per head of the population had mounted higher and higher and it was therefore not desirable to make it go still higher as it would become intolerable. The rate-payers had been paying $17\frac{1}{2}$ to $19\frac{1}{2}$ per cent. of their income and the result was "rackrent" which told severely upon the general public. The result of "rack-rent" was unquestionably overcrowding and its concomitant was havoc of the general public health. All these matters had to be taken into consideration. He was prepared to admit that there were serious defects in the sewers and storm-water drains of the city and he felt sure that what the authors recommended would be taken in hand in right earnest as soon as funds permitted.

Dr. Master said he was glad to hear Dr. Sukhia for the first time in his experience defending the Executive Officers of the Bombay Municipality. The first question raised by that speaker was how to get the money for the proposed improvements. He wished to know whether the Municipality was solvent or not. He was informed that there was a surplus of 26 lakhs of rupees and that it had been suggested that the taxation should be reduced. If 2 or 3 lakhs of this surplus had been given to the Health Department it would have been possible to have a larger number of carts for removing the refuse. The staff was also insufficient but a false economy was being practised. He was not in favour of a reduction in the taxation. Twenty lakhs were at their disposal and some of it should be made available to the Health Department as not only was the service in connection with the removal of town refuse inefficient but the work of the halalkores was also most unsatisfactory. Money, he knew, was everything in the case of sanitation but, he also knew that it was no use removing half the filth of the city and letting the other half remain. The Health Officer had often complained that the city was not as clean as it ought to be, but the Corporation had not met his wishes in the proper spirit. When the Health Department was reorganised a number of extra refuse carts and bullocks

were provided for. New carts were given but at such intervals as only to make up the number of those going out of use from one cause and another, so also with regard to new bullocks. Replying to the question asked by Dr. Nair he desired to state that five lakhs of rupees were being spent in ordering out a new pumping engine, and it was said that this would remove even the sticky matter that usually clung to the walls of the sewers and helped to silt them up. With regard to the question of gradient Mr. Midgley Taylor and Mr. Baldwin Latham had both pointed out nuisance in the Mody Bay sewers. The speaker thought that the habits of the people of the country were responsible for the state of the sewers. They used ashes and some dust for cleaning their pots and pans; this was known to the engineers who constructed the drains and they should have taken it into consideration before deciding on a small calibre for the sewers. Another point was that at intervals there were catchpits by means of which sewage was collected sometimes for a month and generated dangerous gases. The catchpits were all wrong and the sooner they were done away with the better it would be for the health of the city.

In writing their paper the object had not been so much to criticise the actions of the Health Department of the Bombay Municipal Corporation as to bring to the notice of the public the defects in regard to the removal of refuse and to ensure a remedy being applied as quickly as possible. The work of the Corporation in this respect was proceeding very slowly and inconsistently: it was only recently that the Corporation had been waking up. 8 or 10 years ago effective steps were taken to remove all these defects.

When the plague broke out numbers of cart-loads of silt were removed from the sewers at Mandvie proving the defectiveness of the sewer system.

It was necessary to improve the health of the city as much as possible if Bombay was to continue to deserve the proud title of *Urbs prima in Indis.*

The President, in closing the day's session, thanked the authors and those who had taken part in the discussions for the interesting manner in which the Sewage and Refuse question had been discussed at the meeting.

SANITATION IN INDIA.

By J. A. TURNER, M.D., D.P.H.,

Executive Health Officer, Bombay.

The subject of this paper is a very large one—much greater than can be properly dealt with in the time at my disposal. In bringing this subject before this scientific body I will try, if possible, to show what a large field there is in India for the development of sanitation where almost every branch of public health is in itself a problem, where the difficulties to be overcome are so enormous, and where the benefits to be derived are so great. Vast strides have been made in sanitary science during the past 25 years all over the world but especially in England and her dependencies.

Public opinion and the struggle for existence call for increased efforts on the part of Sanitarians to reduce the danger to life and the risk of disease. Much has been done in the way of improved water supply, drainage, sewage disposal and purification, and the cleansing of cities, and our increased knowledge on Etiology and prevention of infectious diseases has considerably reduced the mortality and virulence of these diseases in England. Much has been done regarding the protection of life by laws and regulations for the benefit of workers in factories and child-labour, and the Local Government Board of England plays an important part in the enquiries into the food and milk supply, and the cause and prevention of infectious disease. The duties of sanitarians in England, although very interesting, are comparatively easy compared with the work of their colleagues in the East.

Problems which were difficult 25 years ago now no longer trouble the Medical Officer of Health in England. Public opinion and the powers of the Press, Public Health Acts and by-laws, and the keenness with which the worker takes up his duties renders the solution of such problems comparatively easy. Let us turn to India and, if possible, picture to ourselves the condition of the large cities of this Empire with their teeming millions passively resistant to any modern sanitary methods which inconvenience them. Ignorant, prejudiced and fatalistic, with habits and customs opposed to sanitation of the kind known in the West.

I do not propose to burden you too much with this side of the question although it makes a formidable obstacle in the way of advancement of sanitation. They are obstacles which can only be overcome by patient and constant working, teaching, educating and gradually adopting modern appliances and steadily enforcing the laws and regulations which should be made sufficiently adaptable to the circumstances of the situation.

Sanitary Administration.

The Public Health Administration in England is controlled first by the Local Government Board, a Department of Government. Secondly by County Councils who appoint a County Medical Officer of Health. Thirdly by the urban and rural District Council. In many counties of England there is a County Medical Officer of Health; in addition, there are combined districts comprising Urban and Rural areas, each possessing a whole-time Medical Officer of Health for the combined district and there are also Medical Officers of Health for smaller towns and rural districts. All these officers are appointed by the various Local Authorities subject to the sanction of the Local Government Board and in the majority of cases are whole-time men, half their salary being paid by the County Council out of the County rates.

The Local Authority administers the various Acts concerned with the Public Health, *viz.*, the Public Health Act, 1875, and the Public Health Act, 1890, the Rivers Pollution Prevention Act, the Factory and Workshop Act, Housing of the Working Classes Acts, Infectious Diseases

Notification Act, Infectious Diseases Prevention Act, the Sale of Food and Drugs Act, the Margarine Act, the Dairies, Cow-sheds and Milkshops Orders, Canal Boats Act, Infant Life Protection Act, &c.

In large cities of England the Local Authority is the Corporation, which is divided up into Committees for different Departments,—Health Committee, Cleansing Committee, Lighting Committee, Streets and Buildings Committee, &c.

In London the County Council is the local authority, but for public administration the City is divided into 42 Metropolitan Boroughs and the City and Port of London, each having its own Medical Officer of Health, Engineer, &c.

In India the sanitary administration of many large cities is carried out by a Municipality with a Chairman appointed by Government.

In Calcutta the local authorities are the Commissioners with a Chairman appointed by Government. The Executive Health Officer and the Executive Engineer are appointed by the Corporation.

In Bombay the Local Authority is the Corporation. The Municipality of Bombay is the controlling body and is comprised of a Corporation of 72 members partly elected by rate-payers and partly nominated by Government, the Bench of Justices, the Chamber of Commerce and the University.

The Executive consists of—

The Municipal Commissioner appointed by Government.

The Executive Health Officer appointed by the Corporation subject to the approval of Government.

The Executive Engineer appointed by the Corporation subject to the approval of Government.

In Madras the Local Authority is the Corporators or Commissioners with a Chairman appointed by Government and the Health Officer, a member of the I. M. S., appointed by Government.

In other towns, *e.g.*, Cawnpore, Ahmedabad, Poona, Delhi, Agra, Nagpur, etc., the Local Authority is the Municipality who appoint the Health Officer and Engineer.

The Executive Health Officers of Bombay and Calcutta have Assistants and Deputy Health Officers for supervising the works in different wards. These wards have a population of 150,000 to 250,000 to each and the pay of these officers varies from Rs. 300 to 1,000 per mensem, Cities like Cawnpore, Ahmedabad, Poona, Delhi, &c., with a population of 150,000 to 250,000 each require a Health Officer and qualified Sanitary and Conservancy Inspectors and staff of clerks and subordinates on the same lines as in Bombay, Calcutta and Madras. The Medical Officer of Health should be trained in England, not only holding a D.P.H. but he should at the same time have been actually engaged in Public Health work for at least 2 years previous to his appointment. The Inspectors should possess a certificate of having been under the Health Officer of one of the Presidency Towns and having passed an examination in practical sanitation.

The Port Health Authority consists of a Port Health Officer appointed and paid by Government and his assistants whose duties are to carry out the inspection of shipping entering and leaving the harbour and the disinfection of ships and crews.

The Government sanitary service in India consists of Sanitary Commissioners and Deputy Sanitary Commissioners to Local Governments. Their duties are chiefly concerned with vaccination, but they advise generally on questions in connection with the public health of the mofussil municipalities and districts.

To efficiently administer the sanitary requirements of any district, the officer employed must be completely in touch with the districts or city which he has to control. He must know the object for which he is working and his staff must realise the value of sanitation in other cities and be able to compare and work up to a certain standard of efficiency. The constant changes in the officers connected with Public Health Administration of India and the distances they have to travel is the great bar to any material improvement. Security of tenure of office, adequate remuneration and a high ideal to work up to are the absolute essentials of the Public Health Service.

In India where sanitation is in its infancy there ought to be an augmented staff of Deputy Sanitary Commissioners or Medical Officers of Health. The appointment of ten such officers in the Bombay Presidency, graded according to the population, area and importance of their districts, would result in individual officers being able to devote that amount of care and attention to the sanitary needs of the various cities, towns and villages which the prevailing conditions demand. In the whole of the Bombay Presidency which has an area of 123,000 square miles and a population of 18½ millions, there are only 3 such officers, who have also other duties to perform, chiefly in vaccination. This means that on an average each officer has to supervise the sanitary administration of an area of 246,000 square miles which is nearly a quarter of the total area of Great Britain. In the latter country where sanitation has made such rapid strides and facilities to travel are so much better about 1,000 square miles is the largest area under the administrative control of one man.

Want of funds in many Municipalities and Districts to a great extent prevents the employment of suitable men, but this can be got over by combining districts and appointing whole-time officers whose duty should be to visit systematically their districts and get in touch with the requirements. These officers must be qualified experienced Medical Officers of Health who must be adequately paid, and who must be able to look forward to some improvement in their position. What is wanted is a practical as well as a theoretical knowledge of all branches of Public Health Work, a knowledge of the condition of the city and town and village life and the manners and customs of the people.

The education of a Health Officer of to-day embraces a very large sphere. He must not only be experienced in the questions dealing with the prevention of the spread of disease and the control of outbreaks of infectious diseases, animal and human, but he must have a thorough practical knowledge of sanitary appliances, water-supply, drainage,

sewage and refuse disposal, climatic conditions, sanitary engineering, and all the local conditions affecting the health of the people. But in India he must have a knowledge of transport, cleansing and scavengering of the city and the control of large bodies of men. He must also possess administrative capacity and literary abilities, for clerical work forms a large part of his daily duty.

In addition to these qualifications tact, sympathy, evenness of temper and firmness in dealing with the people and his authorities are absolutely essential in the Public Health Service.

The Sanitary Boards, as at present constituted, have no doubt done some good work in bringing forward proposals for the introduction and improvement of the drainage and water-supply of various towns, but I consider that their sphere of usefulness could be considerably extended by altering their constitution and endowing them with such powers as are possessed by the Local Government Board in England, in relation to the Public Health. As regards the constitution of the Sanitary Boards in the Bombay Presidency, I would suggest that a Senior Officer of the Civil Service, the Sanitary Commissioner, the Executive Health Officer of the Presidency Town, the Sanitary Engineer and two Indian gentlemen, preferably drawn from the ranks of those qualified in Medicine or Engineering, should comprise the Board. The appointment and dismissal for misconduct or neglect of or incapacity in the performance of the duties of all Medical Officers of Health, should be sanctioned by the Board as representing the Local Government. This Board should be empowered to depute one or more of their number to visit and enquire into any exceptional circumstances relating to the Sanitary Administration and requirements of any particular district.

I consider it inadvisable to combine the post of Health Officer with the medical charge of a district, even in a town of 20,000 inhabitants. I fear that such a combination of posts would lead to neglect of the legitimate duties of the Health Officer, resulting in those duties being performed by the Sanitary Inspector; it is moreover opposed to the principle that it should be an inviolable rule that a Medical Officer of Health should not be allowed to undertake private practice. It is hardly necessary to state that the salary of such officers should be such as to obviate the necessity for private practice.

The subordinate supervising staff of the Sanitary and Conservancy Establishment in India is in need of improvement in most towns. Admission to the courses of instruction should be confined to candidates who have passed some examination not lower than the School Final or University Matriculation, and the standard of competency required should be that prescribed by the Royal Sanitary Institute. Such candidates should acquire their theoretical training at one or other of the Medical Colleges in the Presidency Towns, and their practical experience of sanitation should be gained under the supervision of the Health Officer of such Presidency Towns. In the Bombay Municipality there exists a training and examining Board, giving six-monthly courses under the Executive Health Officer.

So far as Sanitary Inspectors are concerned, each local authority should be allowed to recruit its own staff independently. For the guidance of local authorities, and to insure the selection of properly qualified men, Government should prescribe the minimum number of such sanitary appointments for each local authority, the minimum salary to be given to the incumbents of such appointments and the professional qualifications to be required of such incumbents. In order to secure fixity of tenure of these appointments it will be necessary to provide that no Sanitary Inspector should be removable from office without the sanction of the Sanitary Board.

As regards Medical Officers of Health, appointments to or removal from such offices should vest entirely in the Sanitary Board. Such a measure though perhaps conflicting with one of the main principles of local self-Government is, I think, essential for the satisfactory and fearless performance of the important duties on which the health of a town so largely depends. Local self-Government no doubt has been a success in most provincial towns, in branches of Municipal Administration other than sanitary. In the latter, however, owing to the frequency with which private and public interests clash, I consider that an exception to this main principle should be made. I am further of opinion that the mere appointment of such Medical Officers of Health in Provincial Towns will not prove sufficient to remove the existing evils, unless adequate executive powers are granted to them. I am informed that in most City Municipalities a Chief Officer exists to whom the Health Officer is subordinate, and his powers are laid down in Sections 183 and 184 of the Bombay District Municipal Act. But I also find that in the large majority of instances, the salary of the Chief Officer is less than the standard contemplated for Medical Officers of Health. I therefore think it necessary that the status of the Chief Officer should be raised and he should be drawn from the ranks of the Civil Service and invested with the same executive powers as the Municipal Commissioner is in the case of Bombay City. As District Municipalities are at present constituted, all the executive powers are mostly vested in the councillors. Such an arrangement is likely to hamper the Health Officers in the discharge of their duties and therefore any reorganization of the Sanitary Department which does not give a free hand to these officers in the administration of their department will be useless and incomplete. The District Municipal Act should be amended on the lines of the City of Bombay Municipal Act, with regard to Public Health.

In large cities or combined districts with a population of 150,000 to 200,000 there should be a whole-time Medical Officer of Health with a salary of Rs. 500 to Rs. 1,000 per mensem. Under him should be trained and experienced Sanitary and Conservancy Inspectors, one of whom at least should be a Veterinary Graduate on a salary of Rs. 100 to Rs. 150 per mensem. These officers should be elected by the Local Authority subject to the sanction of the Sanitary Board. They should be whole-time pensionable officers and not be liable to dismissal, except for misconduct, without the sanction of the Sanitary

Board. Half the salary should be paid by the Local Authority and half by Government.

In smaller towns where the funds of the districts will not admit of whole-time officers, certain villages and towns could be grouped together to form a combined district and a Medical Officer of Health and Sanitary Inspectors appointed for the whole; they should possess the same qualifications as in the former case and they should be required to live within their combined districts, their pay should be on the same scale as in the former case with an allowance for travelling.

They should visit systematically, and when required, all places in their districts and attend meetings of the District or Local Board to advise on matters relating to the sanitation or public health of the localities.

Qualified inspectors should be appointed for each of the large villages or towns or groups of villages and their scale of pay and allowances be on the same scale as in the former case.

The Medical Officer of Health should make periodical reports and special reports of the sanitary condition of his district to the Local Authority. Copies of this report should be sent to the Sanitary Board. Measures advocated by the Medical Officer of Health not receiving the attention of the Local Authority should be brought to the notice of the Sanitary Board. The pay of these officers should be borne partly by the Local Authority and partly by the Local Government.

In suggesting schemes for water-supply, drainage, scavengering, conservancy, hospitals and the control of infectious diseases, the question of finance will naturally arise and the Medical Officer of Health will necessarily require to take these into consideration.

At the same time with proper supervision by practical men the sanitary condition of a district in India can greatly be improved without entailing large and expensive schemes. For water-supply, drainage and the removal of refuse, certain initial and annual expenditure must necessarily be incurred as sanitation cannot be carried on without funds, but the improvement following on this increases the health and prosperity of the place and its borrowing powers.

In the smaller districts where water-supply and drainage schemes are prohibitive much can be done by supervision of the existing arrangements.

Labour is cheap and land is available for the disposal of refuse. That these smaller districts require proper supervision there can be no doubt and any scheme which does not include some attempt at sanitary supervision will not be complete; the suggestion to group these villages with others and large ones would possibly be of great benefit to the district.

In 1906-1907 I had the opportunity of enquiring into the sanitary administration of many of the large towns of India, *viz.*, Calcutta, Madras, Poona, Ahmedabad, Delhi, Agra, Cawnpore and Nagpur. The largest Cities of India are Bombay, Calcutta and Madras. In Bombay and Calcutta the Medical Officers of Health are appointed by the Corporation subject to the sanction of Government. The Health Officer of Madras, a member of the I. M. S. is appointed by the Local Government. In the other towns the Civil Surgeon is the nominal Health Officer while the Municipality appoint a Local Health Officer and staff.

Practical Sanitation.

The application of our present knowledge of sanitary science to Indian conditions presents many varied and interesting problems.

If the Sanitary Administration of India is to be brought abreast of modern requirements, the staff employed must necessarily be properly trained and experienced men who make and have made sanitation a speciality, and have knowledge and experience of practical sanitation, its application and objects in European Cities as well as India.

Sanitary science as recognised in England is in its infancy in India. It will be necessary here to state what that sanitary science is which should be applied to India.

The development of sanitation and its effects on the health of the people during the past fifty years has been very marked and is nowhere more striking than in the investigation into the cause and prevention of the spread of infectious diseases.

The term "sanitation" has become of such widespread and extensive signification that it may be defined as any measure, method or means which tend to lessen the incidence of disease and produce healthier surroundings, increasing the value of life and reducing the risk of sickness; it deals with the personal, domestic and public surroundings of the individual and of the people, beginning with the work of cleaning the streets and removing excrementitious matter; it is ever developing in some fresh direction; its sphere extends from the sanitary shave in the barber's shop to the practical work of stamping out disease under all conditions and in all climates.

Sanitation, I speak of, includes not only the provisions of sanitary houses and streets, and proper method of drainage and water-supply, and collection and removal of town refuse, but everything which tends to improve public health and to prevent the spread of disease, including the investigation into the causes of sickness and death, the provision of hospitals, medical relief, registration of births and deaths, health visitors and instructions in personal hygiene, and food and milk supplies.

Before going further it may be as well to give in a general term an idea of the sanitary administration of some of the large cities in India, and I cannot do better than to take Bombay as an example as it is as large in population if not larger than any other City of the Empire, except London, and has the most modern system of any City in the East. Roughly, to-day the population of Bombay is 1,000,000 people and what applies to Bombay will equally well apply to other cities in India with some modifications; the population is made up of representatives of every known caste and creed, 75 per cent. being of the working classes.

The work of investigating the cause of and the condition of the spread of infectious diseases is by no means the only part of the duties of the Health Department Administration in India.

The conservancy system which exists in India forms an enormous item to which sanitation has to be applied and which demands the most serious attention. In most of the large cities a sewage system is adopted and the method of dealing with the sewage varies greatly.

In Bombay it is pumped into the sea. In Calcutta into a river, in Cawnpore, Delhi, Agra, Poona, Ahmedabad and numerous other smaller towns the sewage is disposed of on the land, biologically or by irrigation; the solid excreta being removed by hand and dealt with in trenches. This branch of sanitation alone demands radical reforms. The method of collection and disposal of human excreta in India is a danger to the community which it is impossible to over-estimate. Defective conservancy systems are responsible for many outbreaks of infectious disease. The accumulation of human and animal excreta and household refuse near dwellings should at all hazards be prohibited.

In Bombay the majority of the house drains are connected to the sewer. 20,400 proposals have been received for new buildings and additions and alterations to existing buildings during the last 8 years; in which period also 210,564 square yards of public streets were added to the already existing streets measuring 4,065,803 square yards, so that the Municipality were maintaining at the end of the current year 4,276,367 square yards of public streets. The total length of sewers and drains at the end of the current year would measure 219 miles of storm-water drains and 121 miles of sewers including pipe sewers and ovoid sewers.

The number of houses on the water closet system is daily increasing. Thirty million gallons of sewage are pumped into the sea daily at Love Grove Station.

Where water closets do not exist the privy receptacles are cleaned twice a day for each house and carried to the nightsoil depôt and discharged into the sewer. 500 tons of such matter are collected daily and discharged into the sewer in addition to the matter from the water closets.

Owing to the conformation of the Island of Bombay and the want of gradient in the sewers the Shone system had to be adopted in parts of the City, while in the other parts the fall is very slight, the sewage ultimately having to be lifted and pumped to the sea. There is no city in the East where such attempts have been made to improve the system of sewage and where such difficulties have to be overcome.

The cleansing of a city forms the basis of all health reforms and devolves on the Municipality.

The term sewage means all excrementitious and polluted matter capable of being removed by drains or sewers in a liquid or semi-liquid state.

In Bombay the term household and street refuse includes all excrementitious and polluted matter and waste material from houses and shops which cannot be removed by drains in a solid state and includes manure and stable refuse, street sweeping and gully refuse, house refuse, dead animals, &c.

The streets, passages and house gullies are swept twice or thrice a day.

The refuse thus collected is removed by travelling carts and by dustbin carts.

It is the duty of the occupiers of a house to cause house refuse to be deposited in the nearest dustbin cart. This is rarely done, as in the majority of houses the refuse is thrown out of the windows on the side passage or on the street.

It is a common thing to see refuse, papers, food and even more offensive matter thrown out of the windows into the main street directly after these streets have been swept. The habits and customs in Bombay predispose to such methods and these are difficult to compete with.

In order to clean the city at present about—

8,000 men and women are employed.

1,830 carts for scavengering and removing town sweeping are kept up.

3,120 bullocks are maintained.

4,100,776 square yards of streets are swept.

22 nightsoil depôts are provided.

1,000 tons of refuse is removed from the City daily by bullock carts to the loading siding at Mahalakshmi Station and thence by rail to Deonar to reclaim land.

Strenuous efforts have been made to modernise the system by utilising the railways and employing motor traction and incineration.

The Corporation realise the importance of improving the method, and it is hoped that in a short time now haulage by bullock cart will give place to motor traction and incineration. The disappearance from the streets of the dustbin carts and the bullocks will be an immense improvement in the sanitary condition of the City.

If it is difficult to apply our knowledge of sanitation to people in a city like Bombay where there is the advantage of pure water, drainage, scavengering, lighting and constant supervision and investigation into the cause of sickness and epidemic disease, where the streets and passages, privies and houses are cleaned twice daily, where Municipal nurses visit the houses of the poor and advise the parents on the best way of preserving their own health and the health of their children, where the cause of every death is enquired into, where every house is visited to enquire into the health of every new-born child, where vaccination is pressed and practised as in no other city in the Empire, where disinfection and inoculation are provided free, where free camps are erected for the poor and lectures given day and night in the vernacular on how to avoid plague, malaria, small-pox and how to keep the houses clean, where free Municipal dispensaries and free medical outdoor relief are provided for thousands, where every milch-cattle stable has to comply with certain by-laws before it can be licensed, where every factory, oil engine and gas engine has to be passed by the Officers of the Health Department before it can be licensed, and where burial grounds, burning ghats and firewood are provided free for the poor, it is not likely that the inhabitants of smaller cities of India will more readily appreciate the application of modern sanitation.

In England the chief work of the Medical Officer ot Health is the prevention of infectious diseases. The pressure of public opinion and the many interests that are involved clamour for immediate action in controlling an epidemic, and this alone is one of the greatest factors in the Public Health Administration of the West. An outbreak of small-pox or typhoid fever is met with an outcry and an expenditure of large sums of money which, combined with the special arrangements of the Health Authorities, very soon control it.

The Public Health Act of England and its numerous by-laws render the work of the sanitarians comparatively light, their other duties which are directed to the improvements of the sanitary condition of houses, water-supply, food and milk being of a purely routine nature.

In India the outbreaks of infectious diseases are so many and so rapid as to overwhelm the present system of administration, and the difficulties of transit, added to the opposition and ignorance of the people to our modern methods, render the work of controlling epidemics very great. This does not, however, apply altogether in large cities, but the resistance to interference still lingers. Education in the benefits of sanitation, though very slow, is the only means of getting the assistance of the people, without which little can be done.

Registration of Births and Deaths and the Verification of the Causes of Deaths.

All throughout India the system of registration of births and deaths and the verification of the cause of death is imperfect.

In the larger cities some improvement has been made, but owing to the poverty and ignorance of the people many do not seek advice of a duly qualified medical man during their last illness.

The first line of defence ot public health is the accurate registration of births and deaths and the notification of infectious diseases. The following is a short account of the system in Bombay.

There are 22 places for the disposal of the dead, burning ghats or cemeteries: throughout the City, at which Hospital Assistants or Cemetery Clerks are placed night and day.

When a dead body is brought for disposal, if a certificate from a medical man is produced by the funeral party, the death is registered.

Posted in various parts of the City night and day are 32 Death Karkoons and 66 Birth Karkoons.

The duty of the Death Karkoon or Ramosi is to stop every funeral party and inquire into the name and address of the deceased so that the house may be visited by one of the medical staff. He gives a death memo. to the funeral party who produces it at the cemetery or burning ghat. The Hospital Assistant or Cemetery Clerk then makes enquiry into the name of the medical man attending on the deceased, the age, occupation and symptoms of disease, and enters down all these particulars, and, if no other evidence be forthcoming, makes an entry of the probable cause of death.

Deaths so registered are entered in the daily death returns which are sent to the District Registrar of the Section before 8 a.m. each day. The District Registrar or Sub-Registrar then proceeds to the house to verify the cause of death, and, if he has not seen the person previous to death, inquires of the medical man attending. Failing this the cause of death is entered by the Hospital Assistant after making enquiries of the relatives. All the returns are daily sent to the Head Office for tabulation. In the case of infectious disease, action is taken at once to disinfect and carry out the usual precautions to prevent the spread of the disease, trace the cause, vaccinate or inoculate the contacts, &c., and remove any infected person to Hospital.

Similarly 66 Birth Karkoons and 10 qualified Midwives inquire into all the births of children in their district and register and send in their returns daily and issue forms of vaccination to the parents of all children who are not registered or vaccinated.

It is unnecessary for me to point out that, while the actual number of deaths registered is correct, the cause of death in all cases is not accurate or rather the actual cause of death does not always come under the precise heading, and until the Act is amended to prevent the disposal of any dead body without a medical certificate this will always be the case.

Infectious diseases.

Cholera, plague, small-pox and phthisis are fairly accurately returned now, but the causation of many deaths is assigned to fever, and these can only be classified by the history of the cases, from information of the Medical Attendant and inquiries made by the Medical Staff of the Health Department at the houses of the deceased.

It is impossible in this paper to deal with the work done in the prevention of phthisis, or the cause leading to the high infant mortality in India, the high puerperal mortality and the large number of premature births. All these are subjects which require strict and careful attention, and tend to show in what demand improved sanitation is and what an enormous and interesting field for active work in public health and the prevention of diseases exists in India.

The infectious diseases which are most common in India are small-pox, cholera, typhoid, malaria, relapsing fever, plague and measles.

Vaccination and Small-pox.

An enormous amount of work has been done by the Sanitary Administration with regard to vaccination. The control of vaccination is under Government and it is compulsory. The number of deaths from small-pox in British Territories in India in 1906 was 109,583. The number of persons vaccinated was 9,080,313. Of these 738,509 were revaccinated. The cost was Rs. 13,45,072. The percentage of newly-born children successfully vaccinated was 42·6. The death-rate from small-pox is ·5 per 1,000 of the population compared with ·05 in England.

In the large Cities—Bombay, Calcutta, Madras—cyclic epidemics of small-pox occur. The means adopted to control the epidemics are vaccination, isolation and removal to hospital. Much opposition is met with and at

times the strongest measures have to be taken to remove a suffering case to hospital. It is a common thing in Bombay and in other parts of India to see children suffering from small-pox in an acute state being driven about in a public conveyance or carried on the back of a man to a temple. Vaccination, however, is not opposed and many lives have been saved by vaccination.

Vaccination.

Prior to the year 1858 the work of vaccination in the City of Bombay was supervised by one of the professors of the Grant Medical College. In 1858 a special officer was appointed as Superintendent of Vaccination and placed in charge of the Vaccination Department. At that time vaccinations were performed with lymph from arm-to-arm. But in the year 1869 Animal Vaccination was introduced mainly through the exertions of Surgeon-Major Blanc, I.M.S. For a short period much opposition was exhibited to the procedure by the natives; but by tact and patience it wholly disappeared. The Compulsory Vaccination Act was introduced in the year 1877. The City has since been divided into six Vaccination Districts with one Public Vaccinator and two permanent Public Vaccine Stations for each District. Two of these stations are worked every morning, thus giving a turn to each Public Vaccine Station once a week.

The Compulsory Vaccination Act allows the use of animal lymph only and makes inoculation with variolous matter penal. The lymph now in use in the City is exclusively animal, pure or preserved in capillary tubes.

The methods of vaccination practised in Bombay during the last 50 years were vaccination by a single puncture, by multiple punctures, and lastly by scarification. Much controversy was indulged in in the local press in the early eighties as to the insufficiency of protection afforded by vaccination by a single puncture. Those in favour of the method argued that vaccinia being a microbic disease it mattered little whether vaccine introduced into the system was trifling in quantity or large. The Royal Commission on Vaccination which sat in England in the nineties demonstratively proved that greater protection was given in cases where the resulting vesicles were large in size than in those with tiny vesicles. This led to vaccination being made by multiple punctures; and this was again replaced by vaccination by scarification for which a fork-like instrument is used. As natives, except the Parsees, are generally averse to revaccination in ordinary seasons it is thought that the greater the dose of vaccine given in infancy the greater the safety of the individual from small-pox; and by scarification this large dose can be administered. The occurrence of a severe epidemic of small-pox does, however, force many to resort to revaccination. Thus in the epidemic year 1899-1900 the number of persons revaccinated in the City came to 31,168 and the total number of operations was 47,455.

Since 1905 vaccination direct from the calf has been greatly replaced by vaccination with glycerinated vaccine, a mixture of the scrapings of the vaccine vesicles on the calf with four times their weight of a 50 per cent. solution of pure glycerine in distilled water. This is a measure tending to economy and the results are extremely satisfactory compared with those from the calf-to-arm vaccination, the case percentages of success with fresh and preserved glycerinated calf lymph being respectively 98·63 and 98·79.

The following table shows the total number of operations, number successful, the ratio per 1,000 of population protected, the expense on vaccination and the cost of each successful case; the figures are taken for the official years as all the annual returns and reports of the Department are made up according to those years.

—	1850-51	1860-61	1870-71	1880-81	1890-91	1900-01	1905-06	1907-08
Total No. of operations ..	7,584	8,642	11,50[illegible]	16,120	20,70[illegible]	20,[illegible]76	21.481	20,735
Number successful.. ..	6,54[illegible]	7,315	8,358	14,508	19,457	14,035	16.206	15,989
Ratio per mille of persons	..	8·96	10·42	22·43	25·1	17·08	20·88	16·35
Total expense on Vaccination in Rupees	1 68[illegible]	3,492	8.145	13,759	20,428	21,836	23,717	23 036
Cost of each successful case	0-4-1	0-7-8	0 15-8	0-15 2	1-0-10	1-8-10	1-7-5	1-7-1

From this it will be seen that there was a distinct improvement in the outturn of work and in the percentage of population protected, commensurate with the increase in the cost till the year 1890-91, inclusive. But since then the outbreak of plague and the occurrence of frequent famines combined to retard further progress. The regular annual recurrence of plague since 1896 has tended to diminish the number of vaccinations and the frequent occurrence of famines tended to enhance the price of calves. Hence the rise in the cost and the fall in the number of vaccinations. The removal of the Central Vaccine Depôt from the heart of the City to Parel and the exhorbitant rents demanded for the hire of the P. V. Stations in the City also in no small measure contributed to swell the departmental expenditures towards the end of the period. But the fact must not be lost sight of that the period before the Vaccination Act was marked by frequent epidemics of small-pox. Those epidemics are now less frequent and less virulent. Owing to its commercial position the City is always exposed to such epidemics.

Statement showing the number of deaths from small-pox before and after the introduction of the Compulsory Vaccination Act.

Before the Compulsory Vaccination Act.

Years.	No of deaths.	Years.	No. of deaths.	Years.	No. of deaths.
1850 ...	1,308	1859 ...	374	1868 ...	1,123
1851 ...	510	1860 ...	166	1869 ...	1,725
1852 ...	1,003	1861 ...	1,627	1870 ...	556
1853 ...	677	1862 ...	163	1871 ...	919
1854 ...	232	1863 ...	1,059	1872 ...	1 854
1855 ...	1,088	1864 ..	1,707	1873 ...	7[illegible]4
1856 ...	179	1865 ...	567	1874 ...	261
1857 ...	346	1866 ...	1,079	1875 ...	248
1858 ...	1,714	1867 ...	1,055	1876 ...	3,174
				1877 ..	958

After the Compulsory Vaccination Act.

Years.	No. of deaths.	Years.	No. of deaths.	Years.	No. of deaths.
1878 ...	357	1889 ...	304	1900 ...	3,018
1879 ...	479	1890 ...	150	1901 ...	159
1880 ...	207	1891 ...	108	1902 ...	283
1881 ...	35	1892 ...	541	1903 ...	1,477
1882 ...	92	1893 ...	201	1904 ...	568
1883 ...	1,461	1894 ...	531	1905 ...	2,161
1884 ...	112	1895 ...	270	1906 ...	276
1885 ...	55	1896 ...	701	1907 ...	86
1886 ...	19	1897 ...	57	1908 (up to the end of November.)	1,387
1887 ...	108	1898 ...	55		
1888 ...	482	1899 ...	440		
		Epidemic years			

Cholera.

The number of deaths from cholera in British Territories in India during 1906 was 690,519, equal to a death-rate of 3·05 per 1,000 of the population. Many investigations have been made about the cholera vibrio both as to its toxic and hæmolytic properties and many different opinions have been given and the treatment by inoculation inaugurated by Prof. Haffkine was practised for some time but has lately passed away as one of the preventive remedies.

In places where the water-supply is derived from wells disinfection with permanganate of potash is generally adopted during an epidemic. In large cities where there is a good water-supply which is beyond the risk of pollution outbreaks of cholera can be kept fairly well under control, but in all cities there are many wells which are still used by certain classes of people for drinking and bathing and these rapidly become contaminated.

The personal habits of the poor classes is one of the chief factors in the spread of cholera. Crowds of pilgrims attend fairs and festivals in many parts of India. The sanitary and conservancy arrangement is very meagre and the supervision slack. Cholera is introduced and the wells and soil become fouled and when rain comes the contaminated soil and fœces are washed into the nearest watercourse. Thousands of the pilgrims fly from the infected localities only to carry the infection to other parts of the country and many die in the trains and country vehicles and thus the disease is brought into the large towns.

To prevent an outbreak, strict precautions should be taken to preserve the water-supply, isolate the first cases, provide efficient conservancy arrangements and take down the names and addresses of each person leaving the station and forward it to the Health Authority at the destination. This is the practice followed in Bombay. When an outbreak occurs in any locality to which pilgrims go the Health Authorities are written to and the Railway Authorities communicated with. All the stations in the City where pilgrims come are noted and every suspicious case either removed to Hospital or the name and address taken and the house visited for several days.

Wells in compounds and oarts where cases have occurred are treated with permanganate; the premises and drains are also disinfected with izal and treated with crude petroleum to kill flies and larvæ, and every house in which a case occurs is disinfected and the clothes are sterilised and the utensils disinfected. Leaflets in the vernacular are issued giving advice as to what to do and the public and private water-supplies are daily examined bacteriologically.

We know that cholera can be conveyed by water and food and milk, and the direction sanitation should take is to protect these necessaries of life. We also know that it can be conveyed by the personal habits of the people and contaminated utensils. We also know that it can be conveyed by flies feeding on the infected excreta. Sanitation should therefore be directed to educate the people in more cleanly habits, and pay strict attention to the public conservancy arrangements. All latrines and urinals should be properly cleaned and disinfected and treated with crude petroleum which arrests putrefaction and kills the flies, their eggs and larvæ.

The trenching ground, if it is the only means of disposal of excreta, should be well away from the dwellings and to the leeward side, it should not be near a water-supply and the carts or pails which convey the excreta should be kept clean and disinfected. All vacant ground in the neighbourhood of the dwellings should be regularly cleaned and proper latrines and urinals provided.

No hard and fast rules can be laid down as to the method of drainage or disposal of sewage, as each case must be treated on its merits, and this is where practical knowledge of sanitation becomes valuable. The scarcity of water in mofussil towns render a sewage system out of the question. The best method for such places is incineration; a moveable incinerator can now be had which will deal with most of the refuse and excreta from such towns.

Malaria.

In the last report of the Sanitary Commissioner for India the number of deaths from fever as given by him in 1906 is 4,452,842 and he estimates that 25 per cent. of this, or 1,113,210 deaths, was due to malarial fever or a death-rate—4·9 per 1,000 of the population.

Great strides have been made in our knowledge of the cause of malarial fever during the past 10 years Different species of mosquitoes convey the parasite in different localities and much attention has been given to this by recent observers.

The fact that accumulation of water, running water, still water, or sewage and brackish water form breeding places for mosquitoes should be sufficient data for the sanitary authorities to work upon.

In most cities the staff are instructed as to the different species of mosquito and larvæ and the places they frequent; water which can be treated with kerosene oil or crude petroleum (pesterine) is so treated. Drainage and filling in of excavations, the use of quinine and mosquito curtains are advocated.

That there is a good deal to be learnt in the part mosquitoes play in conveying disease is certain, but while waiting for this knowledge the directions sanitation should take are to be indicated. The people should be educated by lectures and pamphlets as to the part mosquitoes play in the propagation of malaria and what should be done to get rid of them. This is the routine followed in Bombay. Much however depends on the people themselves and gradually they are becoming aware of this.

Plague.

In the British dominions of India during 1906, 300,355 deaths occurred from plague, compared with 940,821 in 1905, equal to 1·33 per 1,000 of the population, compared with 4·17 in 1905. Since 1896 to 1907 inclusive 6,023,050 deaths from plague have occurred in India.

The Plague Commission appointed in 1905 published the result of their work in the journal of Hygiene. Major Lamb, I.M.S., the Senior Member of the Commission, prepared a summary of the results which have been freely circulated. I cannot, however, enter into any of the details. It will be sufficient to remind you that after numerous experiments and investigations it was discovered that the rat was the host of the plague bacilli. That the species of rats chiefly responsible were the black rat, house rat and mus rattus, and that mus decumanus, the common rat of Bombay, was also highly susceptible.

It was shown in the report that healthy animals remain healthy in the absence of fleas, even though exposed to infected rats in the same cage, and that when fleas were introduced the healthy rats became infected.

It was found that the infected flea contained plague bacilli in the stomach and that the fæces contained the bacilli.

It was found that rat fleas would bite man and that they could be conveyed by man or his clothes.

That they retained this infectivity for 4 days after removal from the infected rat and that they could be kept alive for 4 weeks when fed on blood.

It is the accepted theory that plague is spread by infected rats and that the rat flea conveys the disease to man. This is the information given by the Plague Commission and it is on this information that the measures for the control of plague are based and until we get some better data we must act on it.

The measures then are to destroy the rats and fleas and prevent their breeding and to prevent their access to man.

In large cities the task of exterminating rats is a difficult one especially in large sea ports.

The rat must be kept from man or man from rats.

Rats should be destroyed, facilities for breeding and food supplies cut off by practical sanitation and improved means of scavenging and cleaning, and well built and, if possible, rat-proof houses provided. All sanitary measures will tend to reduce the incidence of plague.

Crude petroleum or pesterine or kerosene has been found to be a pulicide and it is freely used in all rat haunts and in places where infected rats have been found.

Sanitary Administration.

The City of Bombay, for the purposes of administration of the public health, is divided into 7 wards and subdivided into 10 districts known as Registration Districts. In each ward there is a Deputy Health Officer and in each Sub-Division a qualified medical man who is known as District Registrar, and under him two Hospital Assistants known as Sub-Registrars. The work of these Registrars and Sub-Registrars comprises the registration of births and deaths, enquiring into the cause of every death and verifying it, collecting infomation regarding births and registering them, and enquiring into infectious diseases, including plague, and the measures of disinfection, isolation, removal to hospital and segregation in the health camps. Each office has also a Municipal dispensary and a female visiting qualified Midwife. At every office maps of the respective districts are kept, and on these maps are entered particulars of every infected rat found, *e. g.*, the species with date, and also of every case of plague. The staff of the Health Department are daily engaged in poisoning and trapping and collecting rats. All rats caught or collected are at once despatched to the Parel Laboratory for examination. Next morning the place where infected rats are picked up is disinfected with pesterine, the spot being marked P. R. and date given on the house, the spot on the map of the section being also marked. If the rat is found in a house the house is pesterined and the people kept under observation. It is thus possible to ascertain the probable course the disease will take, and the map and charts included in this report clearly show that infected rats are found some 10 days to a fortnight previous to the occurrence of plague in human beings.

Religious prejudices, caste scruples and habits of the people with reference to Infectious Diseases.

MAHOMEDANS.

The City of Bombay has the fame of being cosmopolitan, Kurds and Tartars from Central Asia having travelled thereto in earlier days and settled therein; also Mahomedans, chiefly of the Suni Sect, from the Plateaux beyond the North-Eastern frontier; also Persians of the Mahomedan Shia Sect, Arabs from the Arabian Peninsula, and the great enterprising commercial community—the Parsis. Hindoos of all denominations and castes from the vast continent of India have settled here from time immemorial. The latter comprise nearly $\frac{3}{4}$ of its population, and Mahomedans nearly $\frac{1}{5}$. The great aim of the Mahomedan religion, in making proselytes in India, was to destroy, in those converted, the castes of the Hindoos with their customs, usages and habits. In this they only partially succeeded. In Gujrath large districts were converted

both by the Shias and the Sunis. The two great Mahomedan commercial communities in Bombay, who hailed from Gujrath, are the Halais and Kachi Memons and the Khojas—the former being Sunis and the latter Shias. Localities were selected by individual affluent and influential Memons and Khojas, whereto flocked others of the same classes converting the localities thus occupied, and now known as "Mohollas." In homes the Mahomedan religion was to a considerable extent successful in destroying caste prejudices, while retaining (to determine disputes and suits) the Hindoo Law and introducing a new element known as the "Purdha system" as also new religious rites with respect to customs at marriages, births and deaths. The Arabs, who were the first to arrive in Bombay from the West with commerce, intermarried amongst aborigines of the island, the progeny being "Matiahs", from whom descended the great Kokni Mahomedan community now chiefly occupying the central portion of the City known as Gogari Moholla and Khara Talao Sections. These, on account of their constant intercourse with Hindoos, acquired many of their customs and habits. In justice to this community it must be acknowledged that many acquired western education and refinement and became highly respected leaders of society; while Memons, being essentially commercial, until only recently stuck to trade The Khojas, the greater number of whom belong to the Shia Sect, being a very pushing and enterprising community, availed themselves rapidly of western education, adopting western habits The Purdha system amongst them now exists only in name. It is this community alone who during the early years of plague availed themselves of isolation hospitals and inoculation. The Borahs, also another Shia community, coming mostly from the Surat and Ahmedabad Districts, availed themselves, to a degree, of the isolation hospitals, but not of inoculation. With these exceptions the Moslem communities have a repugnance to removing their sick with plague, or other infectious diseases, to isolation hospitals, etc. Even when different isolation hospitals were provided in different Mohollas for them, the people were averse to the same and in some hospitals not even a single case was admitted.

The Kokni and Deccani Mahomedans show a great dislike to hospitals and never to any appreciable extent or degree availed themselves of the same: perhaps this may be due to the want of religious or social heads in these communities, the result being that they suffered severely owing to concealment of cases. With the exception of the Khoja community, none of the Mahomedan communities have availed themselves of the advantage of inoculation. How far inoculation has been successful in this community is proved by their relative immunity to plague. The Mahomedans, as a community, prefer their sick to be treated at home and nursed by their relatives whether suffering from infectious disease or otherwise. Although the services of qualified medical men are to a great extent now availed of yet their instructions with reference to infective material are treated with derision and contempt. This has special reference not only to plague but other highly infectious diseases such as cholera, small-pox, measles etc. The infective material is not destroyed, but disposed of anywhere, preferably into houseside gullies. No particular care is taken by the relatives who nurse the sick, although enjoined by the medical attendant, and no attempt at personal disinfection made; hence infection is apt to be rapidly conveyed to the attendants or other members of the house. The backward classes in these communities have recourse largely to Hakims and Vaids for treatment. The Hakims have scarcely any knowledge of personal or public hygiene. Vaccination amongst Mahomedans, being compulsory, is availed of and the children vaccinated, some of them at a very late date. Revaccination amongst them is practically unknown. I shall lightly touch upon the usages with reference to their dead. The Borahs, Shia Sect, in this respect have taken the lead; their dead are immediately removed to the Musjida mortuary where the ablutions and other rites are performed before the final disposal of the remains in the cemetery. All the rest of the Mahomedan communities wash their dead in their houses on low wooden flats or benches provided by the Musjid authorities. No disinfection is allowed in rooms or houses occupied by the deceased for three days and until the end of the "Ziarath" ceremony, the family, in the meanwhile, occupying the room where the deceased suffered, and receiving mourners and guests therein. The backward classes amongst the Mahomedans have a great aversion to disinfection and other sanitary methods. They have a special dislike to sterilizers, in most cases concealing the infected bedding and mattresses, which are either washed at home or sold, or otherwise disposed of. They believe in "Kismath," *i.e.*, fate.

The advent of the Mahomedans, wherever settled in India amongst Hindoos, has been iconoclastic in tendency and led to domestic usages indirect opposition to those of Hindoos. Beef was made the staple food of the classes. The Mahomedans as a rule indulge in mixed diets, while the majority of Hindoos are vegetarians. They will not eat or drink any food that is preserved. The Mahomedan also prefers to eat his food in eating houses or restaurants. The hygienic condition of these eating houses is very bad. The floors are filthy; the tables and benches are unclean; there is practically no store-room for prepared food stuffs, these being placed underneath a stair or in close proximity to a privy, water closet, a "mori" or washing place. Contamination therefore of these food stuffs is frequent and almost certain. These eating houses are licensed by the Police and the Municipality has practically no control over them. On festive and mourning occasions, dinners are served to friends and members of respective 'Jamats" prepared in large cauldrons which perhaps for years have not been tinned. In dinners, one drinking utensil is common to a party, and dinners are served in streets on grounds bare or partially covered by mats if sufficient accommodation cannot be found in houses Only lately a few of the "Jamats" have opened large houses called "Baugs"

for such occasions, but only the rich avail themselves of these. I have had occasions in private houses to notice milk and curds exposed in open utensils next to a privy or on the sill of a window opening into a neighbouring house gully. Further, water for drinking purposes is perhaps never boiled but is stored in "*Gharas*" (mud pots) and copper pots, on the wall of the "mori" or "nahni." One frequent initial cause of the introduction of cholera into Bombay is water brought by pilgrims from the sacred wells of Mecca in bottles and tin cans. This water is frequently mixed with a larger quantity of Bombay water and doled out to friends and relatives. In the houses themselves, amongst the backward classes, in every room, a "mori" is provided which serves as a urinal at all times and a water closet during illnesses. The backward classes on account of certain habits they have, and which they will not correct, misuse water closets and hence prefer privies.

Hindoos.

Three-fourths of the population of Bombay are Hindoos. These are divided into several castes; chief amongst which are Brahmins, Kshatrias, Vaishyas and Shudras. The last include all low-castes. The Brahmins are the priestly caste—highly educated, ministering the religious rites of all other castes. They are essentially vegetarians. The only animal food they partake of is milk. For descriptive purposes all these castes may be divided into two great divisions.

(1) Those strictly vegetarians who include milk in their diet and (2) those who partake of mixed diet. To the former belong the Brahmins, Bhattias, Jains, Shravaks, Banias, Marwadis and Lohanas; and to the latter, Shenvis, Prabhus, Pach-kalsis, Marathas in general, and last of all the Shudras, who eat indiscriminately everything and partake of meal-leavings from all houses.

Until recently the floors of houses occupied by Hindoos o . all denominations in this City were of earth as now obtains in almost all mofussil houses. A recent Municipal regulation enforces that floors should be of "koba" cement and chunam. The practice that obtains in mud-floor houses is to lape them with a mixture of cowdung, red earth and water which gives not an unpleasant coating to the floor; disinfection of them with chemical solutions, even the most potent, is for obvious reasons impossible. The disinfectant fluid unless used in enormous quantities becoming inert. Such house floors are very suitable places for the breeding of fleas. Cowdung may also be the medium or vehicle of diseases, such as diarrhœa, typhoid, tubercle, etc.; animals suffering from specific diseases may also convey by this means diseases to man. Mud floors being soft are availed of by rats to make rat warrens underneath. Experience has taught us that such floors should not be allowed and hence the Municipal regulation enforcing "koba" floors. The practice of laping floors has nearly become innate in the people in so much as even to this day laping is resorted to in kitchens and dining rooms on "koba" floors. It is to be noted that all Hindoos squat and dine on floors. In the first year of plague the people protested violently against disinfection, but experience has proved to them the benefits of disinfection and now without demur they accept it or call for it. The destruction of animal life is repugnant to all Hindoos, especially so to vegetarian classes, *i.e.*, Brahmins, Banias, Jains, Bhatias, etc. Even vegetarians are enjoined by certain rules to partake only of vegetables of a particular kind—thus it is strictly prohibited for Jains to eat any succulent roots tubers, or bulbs, such as potatoes, carrots and onions, while they are permitted to eat the vegetable stalks and leaves growing from such tubers. The meal hours are always during sun-light. The idea not to eat a meal after sun-set is to prevent the ingestion at lamp light of small animals by mishap. Amongst the Bhatias there is a large number of individuals who are known as "Murjadis." "Murjadi" implies the attainment of a higher degree in religion after pilgrimage to the shrine of Gocul. The "Murjadis" will not use shoe-leather or drink water from a service pipe. They are strictly enjoined to drink water from wells. A vast number of houses in Mandvi Section is occupied by such "Murjadis" who, although warned not to drink water from wells, declared by the Municipal Analyst as not fit for potable purposes, will indulge in the same and treat such warnings with derision. There is no alternative therefore for the Municipality, but to fill up such wells or pump them dry. During illnesses, they will avail themselves of the advice of medical men, but take no mixtures except in the form of powders. During the epidemics of plague the Shravaks, Banias, Bhatias and Lohanas suffered severely. These people are all traders and mostly reside in Mandvi on upper floors, the ground floors being used as store-rooms, or godowns for rice, sugar and other wares of this kind. These store-rooms are of necessity infested by rats. The religious repugnance of the inhabitants to kill, or even to remove the rats after they have sickened and died, leads to the infection of houses, and residents of upper floors succumb to the poison. Among Hindoo traders, the Jains and Shravaks suffered most from plague. According to the returns the proportion of deaths amongst them was remarkable, being double of that even among low caste Hindoos.

Isolation hospitals in the earlier years of Plague were held in repugnance by these people as with the Mahomedans. The reasons for this being the same as in the case of Mahomedans. But when private isolation hospitals were established, they availed themselves of them very largely. Inoculation is objected to by these people, the reason they ascribe being the animal origin of the vaccine; although vaccination vaccine is also of animal origin, they readily take it as it comes from a cow or calf which are held in special reverence and veneration. In cases of infectious diseases, no special opposition is met with, with reference to disinfection. Speaking of infectious diseases, Small-pox is venerated in houses as a deity, people refusing to remove cases to hospitals voluntarily. This is a fruitful source of infection to the unprotected and the neighbourhood.

On the 11th day of the disease, when the pustules are scabbing, a patient is conveyed generally in a public conveyance to certain temples where the goddess "Shitala Devi" is propitiated by offerings, &c This is another source of public infection. The Health Department authorities are constantly obliged to proceed against offenders in these respects and get them fined by Magistrates.

The females amongst Hindoos, during their menstrual and lying-in periods, are considered as defiled and polluted. They are set apart in rooms and have no social intercourse, and during the lying-in period are attended by ignorant Dais or Midwives. For this reason the Municipality have now provided 10 diplomæd midwives whose duties are to be helpful during the lying-in period, to assist and advise mothers on infant feeding and to act as Sanitary Inspectresses generally.

When a high-class Hindoo is on the point of death, he is laid on a country blanket (Ghongdy), white or black, and a "Basil" leaf and some holy water are put into his mouth. If a son be present, he takes the dying head on his lap, and, when all is over, the women sit round the body weeping and wailing; the nearest female relatives affectionately caress the dead face with their hands and often use the free end of their "Sadis" to wipe the face. The body is next washed near the steps of the house, dressed in a white Dhoti, transferred to the bier and conveyed to the ghat for cremation. The blanket is then given to the poor.

The lower castes, after the ablution, anoint the dead body with turmeric and butter, while the females, with a free end of their "Sadis," whisk the face, frequently wiping it. The body is dressed gorgeously and thus conveyed on the bier for cremation. All infants and persons dying from Small-pox are usually buried. The whole of the above description applies *mutatis mutandis* in a lesser degree to the mixed-diet people classes. Because of the "purdha nashin system" notification of disease is accepted with great reluctance if at all. Notification of infectious diseases has been more successful during the last decade than in previous years, but the fear and abhorrence of official interference still prevails, with the result that there is much concealment of cases. The wealthier classes of Hindoos avail themselves of qualified medical treatment, the poor classes being unable to do so; the Health Department have established free dispensaries for medical relief; these are largely availed of by the poorer Hindoos and Mahomedans All sorts of ailments, infectious or otherwise, are treated, the Relief Medical Officer, if necessary, attending patients at their homes. The establishment of these dispensaries has led to the better Registration of Births, Deaths and Illnesses.

Parsis.

The Parsis who, in the earlier plague years, were against notification of Plague cases and the use of isolation hospitals, have, since the establishment of the Parsi Fever Hospital by their "Panchayat", behaved in a most exemplary manner in these respects. Disinfection is readily consented to in rooms where deaths occur after the funeral ceremonies are over. Their funeral rites are interesting. When a person dies, after due ablutions, the body is conveyed to the ground floor and handed over to two or four Khandias or corpse bearers. The corpse is then dressed by them and placed apart in a ground floor room on stone slabs, where no one is allowed to approach or touch the body. In the interval before the removal of the body to the Tower of Silence, which invariably takes place in the morning between 8 and 9, or in the afternoon between 3 and 4, a priest (Andhiaroo) continuously chants prayers before the body. Before the corpse's final removal from the house, a ceremony called the "Gaihe Sarna" is performed which consists in the chanting of special prayers by a couple of priests who stand on the doorway. These prayers are made in two parts. During the first part, the body continues to lie on the slabs. This over, a dog is brought in and the dead body is exposed to its gaze for a few minutes. The corpse is then transferred to a bier by Nase salas (special corpse bearers) who alone can consign the body to the 'Tower of Silence," the Khandias carrying the body from the house to the Towers. The second part of the ceremony is now gone through and completed, when the mourners all approach the room where the corpse is to have a last look at it. Further ceremonies are performed for a period of 4 days on the ground floor, the place in the meanwhile being inaccessible to disinfection. The leaders of the Parsi community being well educated have shown an example to other communities with reference to inoculation; but the middle and poorer classes of Parsis have not taken to inoculation to any considerable degree.

Native Christians.

The Native Christians of Bombay consist of mixed descendants of old Portuguese Settlers of Bombay, Goanese catholics immigrating into Bombay for trade and other means of livelihood, and converts from the poorer class of Hindoos and Mahomedans by the Protestant and Catholic Missions. The community, as a whole, is not wealthy and, although in the beginning was reluctant to isolation hospitals, has shown courage and devotion in sending the sick to public hospitals. All arrangements for segregation and disinfection were submitted to without opposition or murmur. They also very largely availed themselves of the free dispensaries and of inoculation. Most of the poorer classes hailing from the northern district of Goa are unprotected against Small-pox and, whenever Small-pox breaks out, this community suffers most severely.

A Short History of the Infectious Diseases Hospitals at Bombay.

The Municipal Corporation of Bombay used to maintain one hospital for infectious diseases at Grant Road, during epidemic seasons only, prior to 1888. This institution was kept open from time to time from 1888—1891,

when, a dispute having arisen with Government as to the liability of the Municipality to maintain a permanent hospital, it was closed. It had, however, to be re-opened on the outbreak of Small-pox in 1892. The accommodation proving insufficient, a branch hospital was opened at Arthur Road; after the epidemic ceased, the infectious diseases hospital was permanently transferred to the latter place. The Arthur Road Hospital thus came into being on the 6th of February 1892, and was the only infectious diseases hospital at Bombay when plague broke out; the first plague patient was admitted on September 24th, 1896. The buildings being but sheds, open on all sides, with earthen floors, bamboo-mat walls and tiled roofs supported on iron pillars and trusses, could not be immediately altered to suit the requirements of a plague hospital and came in for a good deal of adverse criticism; all that was possible to make them comfortable was done, looking to the state of panic at Bombay and the great difficulty of obtaining men and suitable materials for the purpose. When the Plague Committee was appointed by Government to deal with the administration of all plague measures, hospitals were opened at Government House, Parel, Grant Road, Ripon Road, Modikhana, etc., and a number of private hospitals for various communities came into existence. The Jains however were the first to recognise the advantages of a caste hospital; they were provided for in the compound of the Arthur Road Hospital in December 1897. Soon after, the late Dr. K. N. Bahadurjee opened a similar institution for Parsees under the name of the Parsee Fever Hospital. Thus Bombay became possessed of about 40 plague hospitals, extending from Colaba to Mahim, and from Charni Road to Ghorupdeo, Narielwady and Sewri. Parsees, Jains, Bhatias, Lohanas, Banias, Telugus, Sunni and Shia Mahomedans, Borahs, Memons, Khojas, Julais, Bene-Israels, and other communities each had a separate plague Hospital of its own, and there was also one for Shahebs' servants; contact, segregation and health camps were frequently attached to these institutions. In many of the hospitals there was much to be desired in the way of location, equipment, comfort, and adequate treatment; but so long as caste and religious prejudices were respected, the people were content. The Maratha Hospital for Mill-hands was another institution; originating through the labours of the late Sirdar Mir Abdul Ali it became eventually converted into a public hospital for the treatment of plague patients of all communities including Europeans. The compulsory isolation of patients having been abandoned since 1900, most of the caste and private hospitals gradually ceased to exist and the only hospital of the kind now working during epidemic seasons is the Parsee Fever Hospital.

The people, always averse to hospital treatment, became all the more so during the panic engendered by plague. They knew small-pox; they knew cholera; but the devastating influence of plague and its great mortality were an unknown and new experience. In the early days, they could not be made to believe that it was the disease that killed so largely and not the doctors and their assistants; their suspicions culminated in an attack upon the Arthur Road Hospital in 1897, and, later, on the Grant Road Hospital in 1899, owing to similar causes and also on account of the alleged rigour of the plague measures. Advanced communities like the Parsees entertained as well great aversion to hospital treatment, but successive epidemics have to a great extent dispelled such. Various practices were devised by the people in order to elude the vigilance of plague officials, such as secreting the sick and the dead together in the same room within locked doors, hiding the sick under mattresses, beds, straw, and even in large boxes, tying up corpses in a sitting posture near the cooking place, as if they were preparing meals for the household, etc. A change in the plague policy led to a remarkable improvement among the people, but it did not succeed in making the hospitals any more popular. If 12 epidemics of plague with all their painful and bitter experience have not availed to materially alter their attitude towards hospitals, it is impossible to say what will. Thousands of patients have left the portals of our hospitals, hale and sound after plague, but how many have advised their caste men to resort to them? They have had personal experience of the care and attention bestowed and of the devotion for their welfare, but their rooted indifference has been scarcely touched. Sanitary knowledge alone is the remedy, and we shall therefore have to wait for a considerable period before any marked change in their attitude becomes evident.

In spite of the above disadvantages, three of the Municipal hospitals have done good and useful work. To take the Arthur Road and Maratha Hospitals only, there have been treated within their walls (since 1896 and 1898 respectively) 48,372 for the following diseases:—

Plague	22,033
Relapsing Fever	9,542
Cholera	1,615
Small-pox	5,965
Chicken-pox	733
Measles	507
Mumps	52
Whooping Cough	13
Erysipelas	106
General Diseases (observation cases)	7,806

If 1,438 patients treated at the Arthur Road Hospital prior to 1896 be added, the total comes very nearly to 50,000.

THE POLICEMAN AS A SANITARIAN.

By Lieut.-Colonel J. SMYTH, M.D., I.M.S.,

Senior Surgeon and Sanitary Commissioner, Mysore State.

It has long appeared to me that the policeman may be made to contribute much more towards the maintenance of sanitary conditions than he does at present.

Sanitarians in India know well that to maintain ordinary every-day sanitation, the agency must be ubiquitous. The policeman is the only ubiquitous agency, and it behoves us to see in what manner his services can be utilized for our purposes without interfering with the other duties he discharges at present.

So impressed with this are the sanitary authorities in Japan that the police are the executive agency in general sanitation.

Our great fight here is against Malaria, and, in that connection, to get rid of pool formation from whatever cause.

In our towns and villages the police can afford immense assistance. In the rains pools become ubiquitous, but so also are the police.

Bearing this in mind, some five years ago with the co-operation of the then Inspector-General of Police, Mr. Carr, each constable on duty in the town was provided with a small pocket book with leaves arranged in the form of foil and counterfoil. In this was entered by the policeman after his beat was over, the existence and locality of any pools, blocked surface drains, or leaky taps. On returning to the station, the station house officer sent the oil to the Health Officer who immediately took steps to remedy the defects noted by the constable.

This added duty did not require the constable to leave his beat: it merely made him a little more observant.

The results of the procedure are not of course as yet very striking especially as during my absence on furlough it was not rigorously carried out. The procedure is also not one that is definitely laid down as forming part of the ordinary duties of a constable, and till this is done it is not likely to be of great use.

Mosquito Brigades are not easily raised in Mysore, brigades, that is to say, which would be anything more than the name. Hence the necessity for the utilisation of a permanent official and ubiquitous agency like the police. It would greatly increase the usefulness of the police as sanitary assistants if they were obliged to undergo an elementary course of training in sanitation, similar in scope to the "First Aid" course at present prescribed.

The general instructions which now guide the police in sanitary matters are much toc vague, and it would be well if their attention were to be fixed on preventive measures in connection with one or two affections only.

So far as Mysore is concerned, the police rules as regards sanitation may be stated in few words:—they relate

(i) to prevention of public nuisances,
(ii) to prevention of cruelty to animals.

But they are very indefinite, and not distinctly calculated to the prevention of any particular disease.

In India our one enemy is practically Malaria and any loading up of Sanitary Officials with instructions which obscure this fact, and keep Malaria more or less in the back ground, is inimical to the best interests of sanitation, and particularly will this be the case if the Police are burthened with too many details in regard to sanitation. In their sanitary training, Malaria should take the first place, other details being quite subsidiary.

I, of course, write chiefly from the point of view of Mysore. That distinguished statesman, Sir Seshadri Iyer used to say that if it were not for Malaria, Mysore would be one of the finest countries in the world. And he spoke the truth. No one can travel through these hill tracts, with their wonderful scenery and great agricultural enterprises without being impressed with the great possibilities of the country. But when the inhabitants come to be examined, and it is realised to what extent they are the victims of Malaria, how rapidly these tracts are being denuded of the indigenous population, and that work can only be carried out by means of imported labour, the truth of the great Dewan's saying stands out in appalling reality. Compared with Malaria, small-pox, plague and cholera count for nothing, and while, in passing, these troubles cannot be ignored, the one thing for concentrated effort that demands attention is Malaria. I say I write from the stand point of Mysore, but recent reports from other parts of India especially from the north show that Mysore is by no means the only or the greatest sufferer from Malaria; and the object of this brief note is to divert the energies that are at present more or less wasted in other directions to the repression of this the greatest scourge of the Indian people, and to impress on all the necessity for concentrated action against definite diseases, instead of beating the air in a more or less aimless way as is so commonly done at present but against Malaria especially—and leaving unused no agency whose help may be distinctly useful—especially that of the ubiquitous policeman.

DISCUSSION.

Replying to Dr. Turner's Paper, *Lieut.-Colonel Dyson* said that he would welcome some definite pronouncement from the members of the Congress with regard to the lines on which Sanitary Reform in this country should proceed. They had hitherto laboured under many disabilities and discouragements—disabilities as regards the quality and quantity of the staff which they had to work and discouragements on the part of the Executive on whom they had had to rely for the accomplishment of any sanitary reforms. They had often been considered a greater nuisance than any they sought to remove. Time, however, brought its revenge. Recent researches into the origins of disease, more especially in tropical climates, had greatly enhanced the value of preventive medicine while here in India plague had made sanitation a question of increasing

importance in the Councils of the Empire. If, therefore, future generations could point to the early years of the 10th Century as the period which marked the beginning of the sanitary re-generation of India, this scourge which had ravaged the country for the last twelve years would not have been an unmixed evil.

Dr. Turner had sketched a sanitary organisation for this country on the lines of the Sanitary Board of England and its Medical Department. However admirable such an organisation might be he feared it would be found at present too highly organised in practice and too expensive for this country. The present Medical Department of the London Sanitary Board had only attained its high state of efficiency through long years of hard fighting and they had to go back to the early years of the 19th Century in England to find a period at all comparable with existing conditions in India as regards sanitation. Many difficulties had to be overcome—difficulties which were greatly enhanced in this country owing to the constitution of the population and its religious and other prejudices.

The early history of Sanitation in England showed that compulsory regulations beyond a minimum regarding sanitation which were promulgated by the Government against the wishes of the Local Bodies were a failure and had to be withdrawn.

In the words of Sir John Simon "compulsory regulations did not make sanitation more acceptable to the people." What helped to advance the cause of sanitation more than any laws or regulations was the awakening of public opinion throughout the country and this was brought about through the Agency of the Press and Societies whose special object was the diffusion of a knowledge of hygiene. Wide publicity was also given to all sanitary enactments of Government. It was the enlightened public of England which united and compelled sanitary reform. He ventured to submit that these were the lines on which they should proceed in India. Improve and strengthen the sanitary service by all means; no one was more conscious than himself of its present poverty and defects but success in India would depend in the awakening and educating of public opinion. They had to remember that the Press in this country was a powerful organ for good or evil and to enlist this organ in the service of sanitary reform would be to work an incalculable benefit to the country.

Work on these lines had been carried out for several years in Bombay under the auspices of the Bombay Sanitary Association and he hoped Dr. Turner would favour them with some account of the nature and scope of the work done.

SOME SUGGESTIONS BASED ON MOFUSSIL EXPERIENCE, REGARDING THE FORMATION OF A

SANITARY SERVICE FOR INDIA.

By Major F. H. G. HUTCHINSON, I.M.S., and Major J. B. SMITH, I.M.S.

We would preface our remarks by observing that the progress of Sanitation in India has been slow in the past, not because of the lack of expert Sanitary advice, but because that advice remained largely unheeded. When a sanitary proposal comes before a Municipal Council or a District Local Board, its execution or not, often lies to be decided by men whose inherited prejudices are entirely against reform, and who have not, by suitable education, been led to ignore these prejudices. Most of the members of the Board have never known anything better than what has prevailed for centuries. The sanitary proposal is shelved because its importance is not recognised or because of insufficient funds. Funds are however available for other purposes which, to us at least, do not seem as urgent as the provision of a pure drinking water or of some simple scheme for excreta removal.

As Dr. Simpson, formerly of Calcutta, now of London, said, in a paper before the Indian Medical Congress of 1894, "the usual phrase employed against nearly every "proposed sanitary improvement is cost and want of "Funds. By repetition the expression has almost gained "an axiomatic position in Indian Sanitation, and is per-"mitted to pass as something indisputable."

In India—in contrast with Europe—the public press does not interest itself in questions of the general health. But even in England, which is the birth-place of modern sanitation and which at the present time possesses the most efficiently organized Sanitary Service in the world, the control of Sanitary Administration by local bodies is not entirely satisfactory. In support of this statement we would refer to Local Government Board (England) reports Nos. 278, 284, 285, 288, and 289 of 1907 and to the following comments made on them by the *Lancet* (December 21, 1907, p. 1783).

> "It is imposible to look through the series without realizing how frequently the system of Sanitary Government by District Councils of these areas is found altogether inefficient in practice. The Inspectors after reporting on defective conditions of housing, undesirable or dangerous water supplies, neglect to supervise cowsheds and milking and many other matters which become monotonous by repetition, nearly always point to the unsatisfactory circumstances of the local public health service as the first matter in which reform is necessary."

Thus then with the local Municipal Councillor, apathetic towards sanitary reform, if indeed not actually hostile, it is not to be wondered at that progress in sanitary affairs is practically non-existent.

It may appear foreign to the present paper to refer to legislation, but it is to be remembered that the Sanitary Service of England was established by the same Act (the Public Health Act of 1875), which introduced definite Sanitary legislation into the English Statute Book. The lesson ought not to be lost in India. A Sanitary Service can lead to little result until there is definite Sanitary legislation. The English Public Health Acts make a certain minimum standard of sanitation, compulsory on local bodies; other matters are made compulsory on the order of the Local Government Board; and others again are optional. The first thing therefore needed in India is a definite legal minimum of sanitation, which Government

should be in a position to compel local bodies to carry out or if recalcitrant, to carry out at their expense. As in England, certain more extended measures of sanitation should be allowed to rest with local bodies themselves and, in so far, local Government would have play. This is but putting India on an equal footing with England as regards local control of sanitation. If absolute control is not granted to English local bodies, why should it be to Indian?

A Public Health Act modelled on the English Act is therefore needed in India. The legal minimum should, in the first instance, not be pitched too high or too far in advance of Indian public opinion. It is a trite observation that no law which is much in advance of public opinion is likely to secure obedience. If therefore Sanitary legislation is to be effective it is necessary to educate the community at large in hygienic matters. When people arrive at adult age it is practically impossible to influence them. This is especially so in India, where the standard of general education is low, and where there is no public press sufficiently interested in the health of the community to agitate matters of sanitary reform.

The main effort at hygienic education must therefore be made in State-aided schools. Such hygienic education must eventually re-act favourably on the general work of the Educational Department, for it is a matter of common experience that the best mental effort cannot be got out of children who live among unhealthy surroundings and learn in ill-ventilated and insanitary schools.

The policy of the Educational Department has, up to the present, been singularly defective as regards the teaching of sanitation. Hygiene has never yet been assigned as it should be a prominent place in the teaching of the elementary schools. The Sanitary Primer is antiquated and practically useless, dealing as it does with the hygiene of temperate climates and not with that of tropical countries. It has not been revised to keep pace with the rapid advance in the knowledge of tropical diseases. It might for instance be made the means of spreading accurate information regarding plague and plague inoculation, malaria and such like. The elementary schools, which ought to be educative in hygiene, are just as often the reverse, being dark, ill-ventilated and unsupplied with sanitary conveniences. It is seldom one finds in the village elementary schools any more advanced sanitary arrangements than those that were enjoyed by Adam and Eve in the Garden of Eden. It may be said with truth that many of the poorer classes are little more advanced than the lower animals in regard to the disposal of their excreta.

Thus it follows then that when the children educated in such schools attain to adult life, they remain as ignorant of the simplest sanitary precepts as were their forefathers.

In Elementary Schools, and indeed in all schools and for both sexes, hygiene should be one of the compulsory subjects on a level with reading, writing and arithmetic. The teacher, who fails to teach successfully the elementary facts of hygiene, should be regarded by the Educational Department in the same light as one who is unsuccessful in teaching the facts of, say, geography. The teachers themselves should be taught Elementary Hygiene in the Training Colleges. It is quite as important that girls should be taught hygiene as it is for boys; for with the former rests the earlier training of the children of the next generation, and with them also lies the hygiene of the home. In any case it is not sufficient to teach hygiene to only one-half of the population (males) and neglect the other half (females). All schools, but especially Elementary Schools, should be provided with the necessary sanitary arrangements to enable them to be educative in a practical way. Apart from the actual health of the children themselves, a pure water supply and proper latrine accommodation should be insisted on in every school as part of the educational machinery; no school should receive any grant from Government till these were provided, and the grant should be continued only so long as they were kept in good working order. By these means there would, in time, be aroused a sanitary conscience among the peoples of India.

It may be said we are assigning sanitation too large a place in the policy of the State. If so, we err in excellent company. Mr. Chamberlain speaking at a dinner of the Royal Institute of Public Health in 1904 said that "in the seventies he recollected hearing "Mr. Disraeli make a speech, which was at that time a "subject of ridicule from himself, in which he spoke of "sanitary reform as the foundation of every other "reform. To-day they felt that sanitary reform was not "unworthy of the highest statesmanship. Now they "realized that without it social reform was an empty "phrase."

It may be asked what connection the foregoing remarks have to the institution of a Sanitary Service. The answer is that a Service of the most accomplished hygienists in the world will be unable to achieve anything of importance unless backed up by legislative enactments on the one hand and by an educated public opinion on the other. If these be absent the institution of a Sanitary Department on enlarged lines will be a costly experiment doomed to failure.

We would now indicate the lines on which an efficient Sanitary Service can be cheaply provided for India. We only sketch out the broad outline and are well aware that the details would have to be very carefully worked out.

The higher appointments should be recruited from the Indian Medical Service and from among the graduates of Indian Universities. Every officer of the Indian Medical Service in the Sanitary Department should be required to possess not only an English qualification in Sanitary Science but also one in Tropical Hygiene.

It would be a hardship to demand that an Indian aspiring to belong to a Service which the Government of India intend shall be mainly Indian and altogether provincial, should have to go to the expense of proceeding to Europe to obtain a Sanitary qualification. Furthermore that qualification when obtained is not the most suitable one for Indian work. Sanitation in Europe is mainly a matter of ventilation, water-supply, sewage and infectious bacillary diseases. Tropical Hygiene on the

other hand, while including the above, is very largely concerned with animal parasitic diseases and diseases carried by insects. With these latter subjects the British Sanitary Science Examinations hardly deal at all. The Indian members of the Service should therefore be required to have an *Indian* Sanitary qualification.

Hence it is necessary for the Indian Government either to institute a diploma of their own, which is the preferable course, or to cause one to be instituted in connection with the Indian Universities.

The Institution of such a diploma demands the establishment of one Imperial or preferably several Provincial Training Colleges. There can be no doubt but that a public Health College is needed in each Province either separate or attached to some existing institution.

We may point out that the provision of practical instruction in Sanitary Science in the Bombay Presidency is not a new proposal. In 1901 Government appointed a Committee to enquire into the feasibility of instituting a course of "practical training in sanitary Science for students who have passed through the Medical and Engineering Colleges of the Presidency." The Public Health College should preferably be a separate institution in a large mofussil city like Poona rather than in Bombay, where the conditions are so entirely different from the mofussil where most of the students to be trained will find their life work. The school should also have easy access to rural villages where, under his teachers, the student could be shewn what can be effected in Village Sanitation.

The course at the College should be so framed as :—

(*a*) to be recognised by the General Medical Council of the United Kingdom as qualifying for the diploma in Sanitary Science.

(*b*) to qualify for what we shall call for shortness the diploma of Public Health (India).

This implies that there should be well equipped pathological and chemical laboratories with qualified teachers in each. It would be necessary also to have Pathological and Public Health Museums, Library, etc.

The staff should of course possess qualifications in both European and Tropical Sanitary Science.

The work of the College should comprise courses of instruction suitable for :—

(*a*) Officers of the Sanitary Department and others studying for an English Sanitary qualification or preparing for the (suggested) Diploma of Public Health (India).

(*b*) Candidates for appointment as Medical Officers of Health of small Municipalities.

(*c*) Candidates for the posts of "Inspectors of Nuisances" or as we should prefer to call them "Deputy Assistant Health Officers."

Before being allowed to enter for the examination for the Diploma in Public Health (India) the Candidate should be required to work for at least three months, in addition to the course of instruction at the College, under the Medical Officer of Health of a large town.

The reason we insist on the course being framed to meet the requirements of the General Medical Council (of the United Kingdom) is to enable officers of the New Sanitary Department to proceed to Europe on short leave to obtain a British Sanitary qualification without the necessity of further laboratory instruction in England. As we have said the British D. P. H. should be compulsory on that portion of the Sanitary Service recruited from the Indian Medical Service and probably many of the Indian Medical Officers of Health of large towns would also desire to obtain the British qualification. At present the fact that Indian qualifications are not registrable in England stands in the way, but this difficulty will no doubt be removed in time.

We would now proceed to the actual constitution of the New Sanitary Department. This would consist of the Sanitary Board and the Executive of the Sanitary Service. The Government of India consider that the Sanitary Department should be in close touch with the Local Administration and propose therefore that a senior officer of the Civil Service should be a member of the Sanitary Board. We however believe that the Sanitary Board should, to attain its full usefulness, be *expert* throughout and be brought into touch with Government by making its reports, through its President, direct to the member of Council responsible for Public Health. The constitution of the Sanitary Board as proposed by the Government of India—a senior officer of the Indian Civil Service, the Sanitary Commissioner, the Sanitary Engineer and one or two Indians—is we believe defective in that the experts on the Board may easily be outvoted by the non-experts and the opinion of the *Sanitary* Board be merely that of a *lay* Committee. It is undoubted that Indian opinion should be represented on the Board but we think this may best be effected by giving seats to Indian Medical Officers of Health of the first grade.

We would propose, therefore, that the Sanitary Board should consist of the following members :—

The Surgeon-General to Government,
The Sanitary Commissioner,
The Sanitary Engineer,
The Medical Officer of Health of the Presidency town,
Two Indian Medical Officers of Health of the first grade,
The professors (two) of the proposed College of Public Health.

We cannot see any objection to the Surgeon-General sitting on the Board, for it is within the power of Government to call on any officer serving under it for the expression of his own independent personal opinion on any subject referred to him. The opinion of the Surgeon-General on any sanitary matter cannot be less valuable because he has heard and considered the arguments of officers whose opinions may differ from his own. Such a Board would be *purely expert* and its opinions on sanitary matter would be authoritative. The powers of the Sanitary Board should correspond, as far as Indian conditions will allow, with the Medical Department of the Local Government Board in England. Its main function should be to consider important measures of sanitary reform proposed by different local bodies. It is probable that local bodies will rarely be able to carry out any

large measure of sanitation without assistance from Government, either in form of a loan or of a grant-in-aid. It should rest with the Sanitary Board to consider such schemes and to modify them if necessary or even to propose new schemes.

The financial assistance of Government to any scheme should be conditional on that scheme having received the approval of the Sanitary Board.

The Sanitary Board would be able to arrive at a sound opinion on any Sanitary Scheme by the consideration of the reports of its own inspecting officers—the Deputy Sanitary Commissioners.

The other function of the Board would be the sanitary supervision of towns, villages and rural areas; the examination of candidates for the lower branches of the Sanitary Service and collaboration with the Educational Department in the teaching of Hygiene in the Government Schools.

Omitting the Health Officers of towns and Ports, the Bombay Sanitary Service at present consists of a Sanitary Commissioner and five Deputies. The latter are practically Inspectors of Vaccination. We suggest that they should be, what their name implies, Deputies of the Sanitary Commissioner.

Deputy Sanitary Commissioners should, therefore, conduct on behalf of the Sanitary Commissioner, enquiries into the sanitary condition of towns, villages and rural areas; inquire into, on the spot, and report on proposals laid before the Sanitary Board; visit the scenes of epidemics, investigate causation, and suggest means of prevention; inspect the work of Medical Officers of Health of small towns and of rural areas. In other words, the Deputy Sanitary Commissioner should correspond in function, so far as Indian conditions allow, to the Inspecting Medical Officers of the Local Government Board in England.

We have purposely omitted any reference to vaccination as we consider that inspection of vaccination should properly belong to the work of the Medical Officer of Health of a district. It would only come within the ken of a Deputy Sanitary Commissioner when investigating an outbreak of small-pox or the sanitary condition of an area. The Statistical Returns of vaccination should properly go to the Head of the Vaccine Dept, who requires the information they supply for the efficient work of his institution and who can easily compile the Statistical returns for the Presidency.

The Government of India have proposed two grades of Medical Officers of Health :—

(*a*) For towns containing a population of 1,00,000 and over;

(*b*) For towns with a population between 20,000 and 1,00,000 :

and a grade of non-medical Sanitary Inspectors ("Inspectors of nuisances").

We suggest three grades of *Medical* Officers of Health :—

Grade I. "Health Officers" for employment in towns containing a population of 1,00,000 or over. These should be recruited partly from Europe and partly from among the Medical graduates of Indian Universities. The former should as stated previously be required to possess a British Diploma in Public Health and in addition a Diploma in Tropical Hygiene. The latter should be required to possess the (suggested) Diploma in Public Health (India).

Grade II. "Assistant Health Officers."

(*a*) For employment in towns with a population between 20,000 and 1,00,000, and

(*b*) As Assistants to the Health Officers of the larger towns.

These should be recruited from the class of Assistant Surgeons and should go through a course at the Public Health College.

Grade III. "Deputy Assistant Health Officers" for employment as Sanitary Inspectors. These should be recruited from the Hospital Assistant Class and should also have a simple course at the Public Health College.

The term "Inspector of Nuisances" should not be employed. In the first place it is a misnomer in India, the title being in England applied to an Inspector appointed to seek out the legal "nuisances" of the Public Health Act, 1875, and subsequent Acts. Its use is also likely to deter a suitable class of man from applying for appointment. In England an "Inspector of Nuisances" is not a popular official and he would be less so in this country.

But whatever he be called, we consider that his training should be suited to Indian sanitary conditions and his knowledge should therefore be vouched for by an Indian Examination and not by the Royal Sanitary Institute.

The scale of pay proposed is sufficient to attract the best men of the Hospital Assistant Class and we therefore suggest that the qualification of Hospital Assistant be essential to an appointment. Obviously a man so qualified would pick up the training at the Public Health College more quickly than one who is ignorant of Medicine. There would be the further advantage that *all* the Officers of the Sanitary Department would be qualified Medical men. Such men would be capable of diagnosing epidemic diseases (*e.g.*, plague, small-pox and cholera) in small towns and rural areas; non-medical men cannot do this with any degree of certainty.

The Government of India "do not at present propose to discuss the thorny question of sanitation in rural areas." Roughly speaking 280 millions of the inhabitants of India live in rural areas and of these 104 millions live in villages of less than 500 inhabitants. Of the urban population 6¼ millions live in 27 towns of a population of 100,000 and over, and 8½ millions in 216 towns of a population between 20,000 and 100,000. Most will, we are sure, in view of the above figures agree with us that any scheme that does not touch the rural areas is defective.

We do not deny that the question is beset with difficulties, but the simpler measures of sanitation applicable to a village are more easy to carry out than are the larger problems affecting even small towns. All villages come within the control of District Local Boards who at present have no health adviser, but depend for expert

sanitary advice on village sanitation books written up, for the most part, by *untrained* Sanitary Inspectors, but occasionally by Deputy Sanitary Commissioners. In this Presidency the Civil Surgeon is seldom, if ever, a member of the District Local Board. As District Local Boards must have expert sanitary advice, we think that one or more (in accordance with the size of the district) Health Officers of the third grade (trained Hospital Assistants) should be appointed as Medical Officers of Health to each District Local Board. They would take the place of the present Sanitary Inspectors, and their professional work should be under the direct supervision of the Sanitary Board. When more money is available, the Medical Officer of Health to the District Local Board might be a Health Officer of the second grade (trained Assistant Surgeon) and under him would be Health Officers of the third grade as Sanitary Inspectors or as Medical Health Officers of Taluka Local Boards or groups of Taluka Local Boards. This arrangement would assimilate the Indian Sanitary System to the English, where there is a county Medical Officer of Health with Medical Officers of Health for combined rural areas within the county.

Many small towns would be unable to support a Medical Officer of Health of even the 2nd Class. Where the town happens to be the Head-quarters of a Civil Surgeon the difficulty may be got over by the employment of a Deputy Assistant Health Officer (Hospital Assistant), working under the supervision of the Civil Surgeon who is, as a rule, a member of the Municipality. It is impossible, under modern conditions, for a Civil Surgeon to do any appreciable amount of effective inspection.

The efficient discharge of the duties of a Medical Officer of Health must so often conflict with the personal interests of members of the Local Authority that, if he is to have any independence of opinion or of action, his position must be absolutely assured. This is not a fanciful statement but based on English experience and that of a recent date. The salaries of efficient Medical Health Officers have been reduced owing to members of the Council being " personally hostile " because the Medical Officer's " zealous discharge of his public duties had been prejudicial to their private interests " (British Medical Journal, Vol. II, 1907, page 538). In one case, (Southend-on-Sea) it was reported to the Local Government Board that 4 Medical Officers of Health had been appointed in 5 years and " that as each Health Officer had become unpopular in turn with his Authority through pressing forward needed improvements he, as a result, failed to secure re-election. " If such things happen only too frequently in England, is there any reason to suppose they will not happen in India ? The most efficient remedy for this state of affairs is the institution of a Provincial Service of Medical Health Officers.

An alternative proposal to a Provincial Service is that Government should lay down

(*a*) The minimum salary to be given,

(*b*) that no Medical Health Officer should be removeable without the sanction of Government or of the Sanitary Board.

English experience shows that these safeguards are not sufficient. Reduction of salary to the legal minimum has been the method adopted by local bodies in England to cool the zeal shown by Medial Officers of Health (*vide* case of Medical Officer of Health, Cheltenham, "British Medical Journal" December 14, 1907, p. 1731). Efficiency therefore in a Medical Health Officer would be less likely to lead to increment of salary than would subserviency to the Local Body. The pay of any Medical Health Officer should therefore be absolutely independent of any Local Body. He should be an Official of Government lent to the Local Body just as Medical Officers are lent now.

As a competent knowledge of the language, customs and religious prejudices of the people is essential for efficiency in the Officers, both European and Indian, of the Sanitary Service, it is desirable that, while there should be one Provincial Service, the services of each officer should be confined as much as possible to one language district, for roughly speaking the people in each language district have the same customs and religious prejudices. We would further add that each Officer of the Sanitary Department should have a really good colloquial knowledge of the local vernacular.

The question of an Imperial Sanitary Service may come up in connection with this discussion. It is sufficient to say that it would be as reasonable to suggest a homogenous Sanitary Service for the Continent of Europe as one for the sub-continent of India. The varying languages, customs and religions would make such a plan unworkable for no officer could in the course of his service make himself familiar with the different parts of India, and in transfer from Province to Province he would necessarily be entirely in the hands of his subordinates.

DISCUSSION.

Dr. Pearse said :—He felt sure all present would agree with him that they had listened to two very interesting papers dealing with sanitary administration in India and with various suggestions for its improvement. Two points in particular had struck him. First was the variety of powers sanitary administrations possessed in Presidency cities, in mofussil towns and villages. What in his opinion was required was a consolidated Public Health Act for the whole of India with a subsidiary Act giving larger but uniform powers for special areas. The second point was that a large part of the work of sanitary experts was hampered or even interfered with by the various lay sanitary authorities. It was absurd that small sanitary improvements provided for by the various Municipal Acts should be dependent upon the will of Committees of Corporations composed of pleaders, merchants, shopkeepers and others who had no expert knowledge and who frequently interfered with the action of sanitary officials in the discharge of their duties. The civilian sanitary authority must necessarily control large schemes involving considerable expenditure but that it should have the power to restrain or even neutralise the action of a Health Officer in regard to improvements of latrines, drains or cattle sheds, was against sanitary progress. As an illustration he mentioned the difference in methods of dealing with houses unfit for human habitation in Bombay and Calcutta. In Bombay the Chief Engineer could deal with such houses but in Calcutta the Health Department had to prove to the satisfaction of the Magistrate that a particular house was not fit for human habitation. Again the Health Officer of Calcutta had to get the sanction of the Standing Committee before he could take action for enforcing the improvement of a stable or for

the conversion of a hand service privy into one adapted for flushing by water. Delays and even impediments to action constantly occurred as a consequence and improvements were retarded.

He urged for these reasons that larger powers in the administration of the public health section of the Municipal Act should be placed in the hands of the Health Officer, that less control in minor matters should be entrusted to Municipal Committees and that matters of a technical character upon which only experts could decide should be entrusted to a body of experts and not left to the uncertain and indiscriminate control of lay bodies. He fully concurred in making the tenure of appointment of an Health Officer independent of the electing body and that he should be in such a position as to be free to discharge his duties without fear or favour.

Dr. A. G. Newell (Madras) said that he was fortunate to be present to listen to Dr. Turner's interesting paper on Sanitation in India, with special reference to Bombay and he was sure all present agreed with him in saying that Bombay was most fortunate in having one who was so ably struggling under many difficulties—mainly connected with the customs of its heterogeneous population—and the Profession in general and the Sanitarians in particular must be proud of one who was carrying out sanitary measures with such ability, energy and devotion. Very few could appreciate as he could who knew the actual internal conditions of practically 60 per cent. of the native houses in this city what a vast problem the Municipality had before it, and, although there always would be complaints (and these when well grounded should always be sent to the Health Officer direct as it helped him to get at nuisances, &c.), still taking everything into consideration he could but hold that the Bombay Municipality was doing its best to maintain the city according to its motto—*Urbs prima in Indis*. He thought that the citizens and the leaders of the various communities especially were not doing as much as they should do to further the public Health Administration and the prevention of disease. If some individuals who eloquently decried the Municipality at every opportunity would use their elocutionary powers with the same zeal on the citizens and leaders, not only would they be doing much good to the city and to the object they appeared to have at heart but also they would the more becomingly adorn the community to which they belonged. Urgent sanitary matters pertaining to Bombay seemed to be its water-supply, a more rapid removal of its refuse, demolition of insanitary houses and the improvement of insanitary areas. With reference to sanitation generally in India, he regretted to state that it was so far behind. For that he thought the Government of India was chiefly to blame. Such sanitary measures as were carried out in this country, excepting those of the few larger cities, were vaccination, inoculation and a few schemes which were recommended by the Sanitary Boards from time to time. Sanitary measures carried out in this way must be termed "patch work Sanitation." Anything like general measures for the prevention of disease and the improvement of the health of the people as would constitute preventive Sanitation was in the main neglected. The Government of India, it seemed to him, was marking time and he considered it was time they were asked to march onwards with the results of the latest researches now before them. The country, generally speaking, was liable to suffer from malaria, plague, small-pox, cholera, typhoid, dysentery and infantile diseases (to mention its chief afflictions). All of these were preventable diseases, but beyond vaccination and inoculation against Plague the Government enforced no measures for the prevention of disease or for the improvement of the health of the people. The existence of so much malaria in this country was a disgrace to the Government, which beyond giving out quinine (which alone would not exterminate it) did not pursue or enforce methods of prevention but rather, by permitting Railway excavations and excavations of the Public Works Department, placidly accelerated the chances of infection and the further spread of this disease and the deterioration of the people's health.

The very high infantile mortality rate was no credit to the Government of the country and, though he admitted the difficulties in this direction were great, still nothing had been attempted by the Government in any way to diminish it. The great prevalence of such an easily preventable affection as ankylostoma was a measure of that Government's apathy. Government could easily force all Municipalities, all factories and all estates employing labour to establish sufficient latrines. It was the duty of Government to enforce proper medical and sanitary arrangements being made by all agencies employing labour rather than leave it to the whim of the Manager in charge.

Village sanitation was important, and the sanitation of small towns required immediate attention. If the sanitation of small towns and villages were taken in hand early when they could be easily dealt with, it would prevent these places (which in the future would become cities and towns) from lapsing into insanitary cities and towns giving rise to difficult sanitary and financial problems, and further becoming penalised by Improvement Trusts. If more attention were given to villages and small towns and the erection of insanitary houses in them were prevented, much of the insanitary conditions in towns would be prevented and the health of the people improved. There was only one remedy and that lay in the formation of a distinct Sanitary Service in India and the enactment of a Public Health Act which would be applicable to India and could be modified for the various Provinces. Both these the Government of India could give if they had the will to do so, and the insanitary condition of the country and the prevalence of many preventable diseases in it demanded these. The head of the Sanitary Service—the Chief Sanitary Commissioner—should, he thought, have a seat on the Viceregal Council. He, with the Sanitary Commissioners of all the Provinces, should be eligible for the Chief Sanitary Commissioner's post and they should act as intermediaries between the Board and the Medical Officers of health to whom they could give advice in special cases. The Medical Officers of health should receive at least Rs. 500 per month for the small towns rising to Rs. 1,000, should have security of tenure, and be pensionable and eligible for the post of Provincial Sanitary Commissioner. The I. M. S. officers should be retained entirely for the Indian Army. The present Civil Surgeons should, he suggested, be converted into a Civil Medical Service connected to which should be all dispensaries of the country which would relieve Municipal finance and responsibility. For a few years special Health Lecturers should be appointed by the various local Governments who would go among the people and give lectures on hygiene in various languages. This would do more good than the circulation of billions of leaflets. Research institutes should exist in the Capitals of all the Provinces. Elementary hygiene should be made a compulsory subject for the B. A. and M. A. examinations in all universities and the essence of hygiene taught in all schools in certain classes. Government should appoint a special examiner to set papers and examine candidates for Sanitary Inspectorships, so that one standard of men would be produced and one uniform standard of work performed throughout the country. A three months' course in practical sanitation should be compulsory, and no course at any college or institute recognised which had not satisfactory apparatus.

Rat destruction throughout the country should be carried out by Government by a special staff under the Medical Officers of Health but at seaports the expense should be paid for Internationally. All ships should be claytonised.

The country needed the adoption of these measures which were the legitimate results of the hopes and aspirations following on the beneficial action of civilising influences. It was from Sanitarians of the Bombay Medical Congress that further progress could be ensured, and so he proposed the following resolution:—

"That this Section of the Congress through H. E. the Governor of Bombay calls upon the Government of India, to institute a sanitary service and a suitable Health Act for India."

The consideration of this resolution was postponed till the end of the day's sitting.

Major Clemesha said that it never did anybody of men or individuals any harm to see themselves as others saw them. They had to remember that the eyes of the Government were upon them and it was therefore advisable to take the outside view of their ideas and see how they were likely to strike the people who ruled the country as they were the persons who would have to be consulted in regard to any reforms in a country like India.

As regards Dr. Pearse's remarks about the unnecessary element of civil criticism it was a subject which was somewhat Eutopian and difficult to do away with. The further it was necessary to go into details the more apparent became the trouble. On broad lines they had to accept the criticisms of the civil element which had to consider ways and means. He considered that the great fault of all the papers which had gone before was that they did not deal with the cost of the sanitary purposes advocated. It was, he thought, quite possible to overstaff the sanitary service. There was absolutely no use for a sanitary service where there was no money to spend on the sanitary works they might recommend. A great deal of the money that would be spent in travelling allowances, batta, &c., of Sanitary Inspectors and other Officers might well be diverted into building village wells, restoring the coping of wells, &c. He agreed that an advising staff was necessary but it was quite possible to over-advise and to spend too much on this instead of carrying out actual works of necessity. He thought the population of a district was not a criterion for the appointment of a special Health Officer. The numerical test was not always safe as it was quite possible to spread a lakh of human beings over a barren country, and it would be difficult to suppose that a sanitary staff would, under such circumstances, be a vital necessity and it was patent that a barren country could not bear taxation. He was of opinion that the fairest method was to estimate the revenue of the district and not the number of the people inhabiting it. He spoke, he said, from considerable experience in Bengal and Madras. He gave in support of his contention the case of Chapra which was a populous and wealthy district with a good revenue. But it had to be approached through poorer towns which, because Chapra was a trading centre, had to maintain good roads practically for the benefit of Chapra.

He was not in favour of increasing the number of highly paid Officers in the districts and he was opposed to increasing the labours of Civil Surgeons by asking them to look after sanitary matters as they had all the burden of other work thrown upon them, and it was not fair to expect them to do sanitary work as well.

The class of Sanitary Officer for which, he thought, there was a demand, was the well qualified and responsible Sanitary Inspector who could do a very great deal in small districts. Health Officers on Rs. 250 a month were not the kind of Officers required there, only wealthy districts could afford them. In small districts what was required were Officers on from Rs. 25 to 30 per month.

Dr. Sukhia said that the last speaker had taken the wind out of his sails as he also was an advocate of ways and means. It was easy enough for anyone to recommend various reforms but it was only reasonable that bodies like Government and Municipalities should have to look to their resources and finances to meet the demands made for sanitary objects. They had to look to the fact that the taxation had already increased and was still increasing and in Bombay it was Rs. 6 per head of the population and had gone up to Rs. 10. If the burden were to increase in the same ratio it could not be easily borne. Coming to what Dr. Newell had said with regard to the excavations of railways alongside the lines, &c., and of excavations made by Municipalities and other bodies, several cases had been dealt with but before that havoc had been done to the population. It was not desirable that there should be a long tenure for medical officers of health as that would lead to them becoming fossils. They would not keep pace with the march of science. There should be a renewable term of from 5 to 7 years. If the officer kept up his reading, etc., and continued to be competent he would be all the more valuable for the experience he had gained and he would have no reason to be apprehensive about the tenure of his appointment.

Remarks had been made by one of the speakers to the effect that certain bodies were recalcitrant. When Executive Officers tried to force the hands of certain bodies they became recalcitrant because they came with so many demands that could not be met. They had to remember that without ways and means it was not possible to push forward any reforms.

He was extremely glad that Major Hutchinson dealt with education in sanitary science in schools. Primary education the speaker thought, should also include a little hygiene.

He wished to draw attention to Dr. Turner's paper as there was a serious misconception there as to the death ceremonies of the Parsees. The author had himself fallen into the error or he had been misled by his advisers. The statement about Parsee corpses made by the author was incorrect and was a far-fetched one from whomsoever it had emanated. The Parsee priests recited prayers over the dead since the advent of Zoroaster. In Persia it was very cold. Snow lay upon the ground for considerable periods and so the body could not be taken away and the relatives had to make provision for the protection of the body by arranging for a priest to sit by it, who, in order to counteract any effluvium which might emanate from the corpse, burnt incense and frankincense and myrrh as a disinfectant while he chanted prayers and protected the corpse from possible desecration by wolves and stray dogs. The ancient practice carried out in Persia had been continued here not because of the fear of voracious animals but simply because no kind of domestic animal should touch the corpse.

Dr. Turner said he accepted Dr. Sukhia's statement in regard to this point unreservedly.

Khan Bahadur Dr. N. H. Choksy (Bombay) said: – This Section should feel grateful to Dr. Turner for drawing its attention to the greatly increased needs of a proper sanitary service for India. The memorable Resolution of the Government of India of last year outlined certain broad principles for its organisation, and it was laid down that qualifications, merit and ability being equal, preference for the posts of Sanitary Officers would be given to Indian Candidates owing to their familiarity with the languages, religious usages and social and domestic customs of the various peoples. It was to be hoped that this subject would engage the serious attention of Government after the Reforms Scheme became finally settled. The Indian Universities must also bestir themselves to lay down adequate courses for study and examinations in public health. No better schools for the practical study of Indian problems of sanitation could be forthcoming than the departments of public health of the principal cities of India, each with its own special needs and requirements and each presenting an object lesson in practical sanitation.

(1) Small-Pox.—He ventured to offer a few observations upon the prevention and spread of some of the common infectious diseases, inasmuch as he had been concerned in their Hospital treatment for the last 22 years. Among the infectious diseases referred to by Dr. Turner, Small-Pox possessed for them problems of special interest. It had been practically endemic in this city since 1896, except in 1897, 1898 and 1901. Seven epidemics of varying incidence and severity had prevailed during this long period and in spite of vigilant efforts of vaccination and re-vaccination, it did not appear to lessen its hold upon this City. This state of affairs must be remedied by largely encouraging re-vaccination, as also primary vaccination among the unprotected and isolation of the sick. As only less than half the number of the reported cases were isolated in Hospital, as shown by Dr. Turner in his last Report, it was not difficult to realise how those remaining in their houses were liable to keep up and perpetuate the infection. The popular prejudice against hospital treatment of Small-Pox required to be broken down and in this regard the leaders of the people ought to afford material help. The masses should be impress-

ed with the great saving in life that occurred from Hospital treatment as compared with home treatment or rather from sheer neglect. The mortality rate among the latter had been 62·81 per cent. whereas the hospital rate was but 25·66 per cent. This could be still further reduced if patients could be induced to seek admission early in the course of the affection. The great influence of even one successful primary vaccination was well brought out by the statistics of the Arthur Road Hospital which indicated that the mortality rate among those vaccinated once in infancy be it good, bad or indifferent, was considerably less than among the unvaccinated. The rate among the vaccinated varied between 7 and 20 per cent. as contrasted with 30 to 60 per cent. among the unvaccinated according to the virulence of the infection.

Apart from the above strictly local causes within the control of the Health Officer, there existed several extraneous circumstances over which he had no control and which were responsible for the frequent recrudescence of Small-pox. Those were (*a*) the annual influx into the City of unprotected or but inadequately protected persons, who gravitated in large numbers in search of work, domestic service, &c., (*b*) the influx of unprotected Hajees on their way to and from Mecca, and lastly (*c*) the arrival of a certain number of unvaccinated and susceptible infants, from outside the City limits.

Under the first heading were comprised the labouring classes from this Presidency, mostly inadequately protected or but with one primary vaccination, as also people from Goa who flocked to Bombay annually in large numbers for domestic and other service. The former class should be dealt with in the district from whence they migrated. It should be widely notified all along the Konkan and the Ghats that people proceeding to Bombay should get themselves vaccinated or re-vaccinated. Having no prejudice against the operation, they would readily fall in with this suggestion if properly approached. The latter class, Goans, could not be so easily controlled, as they were Portuguese subjects. But inasmuch as they were allowed to resort to this City in order to earn their livelihood, they become easy prey to the disease owing to their unprotected or but imperfectly protected condition, and spread it among the resident population.

It was now several years since Dr. Choksy drew the attention of Col. Weir, the then Health Officer of the city, to this aspect of the Small-pox problem, suggesting to him the desirability of enforcing vacciñation on all Goans before they were allowed to land from the steamers. He took up the question, as also did Dr. Turner, but political and other considerations stood in the way and we were, he believed, as far off to-day from that consummation as we were 15 to 20 years ago. He thought a vigorous protest from the Municipal Corporation was needed to rouse the authorities and he felt confident it would have the cordial support of all interested in the well-being of this City.

The second group related to the Hajees. Their question possessed more than a local interest, inasmuch as they were drawn from all parts of India. The largest proportion of sufferers from among them belonged to the cultivating classes from the province of Eastern Bengal, Assam (from Barisal, Faridpore, Bogra, Dacca, Comilla, &c.,) and a small proportion from the Madras Presidency (from Mangalore, Cannanore, Calicut, Cochin, &c.). The Governments concerned should be asked to take action in order to see that all unprotected Hajees got themselves vaccinated before they started from their homes for the pilgrimage. And the Local Government might influence the Hajees, through the Haj Committee recently appointed by it, to similarly get the Hajees to undergo the operation.

In addition to the above measures, all contacts of Small-pox instead of being allowed to spread over the country after disinfection of their personal effects, as at present, should be segregated at Bombay until the period of incubation was over and all further risk of the disease developing in them was thus obviated. As for the cost of isolation and segregation the Provincial Governments concerned should be asked to bear a part, even if not the whole, of such expenditure that was a recurring burden upon the finances of this City. If they were made to pay or share the cost, it would be to their interest to see that more vigilant preventive measures were adopted than hitherto. As it was, ti was unfair to this City to be saddled with the cost of treating Small-pox cases not belonging to it. The same principle might be made applicable in the case of Goans to the Portuguese Government of India who should be held responsible for the due protection of its subjects. The above proposals might at first sight appear somewhat drastic, but he would put it before this Congress whether such a City as Bombay was not justified in imposing its own conditions upon aliens who proved a menace to its health and well-being? A few cases from other races similarly unprotected comprised Arabs and Somalees from the dhows and Negro-Africans from other vessels.

The third group or infants born outside the City limits, but brought into it during the first year, should be dealt with as in the first case, through the village Patels and Revenue Officials enforcing compulsory vaccination before the parents were allowed to leave their villages with their unprotected infants.

Dr. Choksy then went on to say that the above considerations applied to imported Small-pox or unprotected cases falling easy victims to infection lurking in the City. The Corporation were however able to deal with inadequate protection within its Municipal limits. They had a compulsory Vaccination Act for enforcing primary vaccination which the people did not object to, and, if they at all evaded it, it was more through ignorance than prejudice. Compulsory re-vaccination was suggested by Dr. Turner but was lately disapproved of by that body, as it apprehended that it would go against the prejudices of the people, apart from its being an instrument of unnecessary hardship.

In his opinion a beginning should be made for voluntary re-vaccination of school-children and labourers and this, together with the steady advance of re-vaccination amongst the better and more intelligent sections of the population, would eventually prove efficacious in lessening its ravages at least and finally in altogether eradicating Small-pox from our midst.

(2) Chicken-Pox.—Chicken-pox was another affection that was imported into Bombay. Fortunately it was but rarely fatal, as it had not hitherto assumed any serious manifestations such as those described in the text books. In all his experience of 21 years he had scarcely noted a single fatal case. The persons most liable to it were the Bengali Lascars of the vessels plying between Bombay and Calcutta. They generally developed the disease during the voyage. As they were isolated on the boat reaching this Port, not much harm was done.

(3) Cholera.—This City was in a better position to prevent the importation and spread of Cholera than of Small-pox owing to the generally known sources from whence it emanated and the efficacy of the measures of train inspection, isolation and surveillance of contacts adopted by the Health Department. In spite however of all these, occasional instances did occur when unpaved wells became infected through the people washing soiled linen in their proximity. If, in conjunction with the above, they had adequate control over the gathering grounds and catchment areas of their lakes, in order to prevent contamination, there ought to be no fear of such wide-spread visitations of Cholera as once used to give a by-name to this City, prior to the introduction of the supply from the Vehar Lake.

(4) Plague.—As he had been concerned more with the curative than its preventive aspects, he was not in a position to say much upon the prevention of Plague. They were all but too familiar with the history of the last thirteen years with all its horrors and all its experiences. The three measures that had been proved efficacious in limiting its incidence were inoculation, rat destruction and evacuation. But so far as this city was concerned, inoculation, it must be admitted with regret, not less than with humiliation, had not met with popular approbation, in spite of long and persistent efforts. Lectures, demonstrations, leaflets, personal example and above all the sad and bitter personal experience of the loss of near and dear ones had failed to arouse the people from their apathy and

dispel their prejudice against this protective measure. They would not submit to the prick of the needle, even if it be to save their lives. Oriental fatalism could not be better illustrated; it continued to baffle science. Whether the latter would eventually be the victor in this bitter conflict none could foretell. There was just one ray of hope that might lead to victory, and that was the exhibition of the protective vaccine by the mouth. Should the observations now being made by Latham and his collaborators demonstrate that bacterial vaccines would be just as efficacious when thus administered as when applied subcutaneously, the battle would be won and they would be enabled to achieve the too long-looked for result, *viz.*, the universal immunisation of the people against plague. Until then he was afraid fatalism must have full sway.*

(5) RELAPSING FEVER. The conditions that led to the importation of Relapsing Fever into this City, now no longer existed. Famines and their sequelæ were solely responsible for it. So long as famine refugees were not prevented from entering the Municipal limits of this City or not segregated thereafter, the recurrence of this fever was inevitable during such periods. Apart from these conditions however the disease was bound to lurk amongst the destitute and poverty-stricken in the slums of such a large City. The Health Department was doing all it could to cope with it, and the danger of any widespread epidemic was in his opinion not to be feared.

Rao Bahadur Dr. K. V. Dhurandhur, F.R.S.I., Sanitary Commissioner, Baroda, said that for a long time he was the first on this side of India to take up sanitary work. Dr. Turner's experience had been very short but he had taken such a broad view of the whole subject that it was most creditable to him. He thought that there should be a central organisation, without which every effort would fail. There should be one for the whole of India with branches for every Presidency and Province. He did not agree to highly paid sanitary engineers. The central organisation would give ideas and guidance. What was required in villages was the removal of filth. Once that was arranged for, one-fourth of the work of sanitation was accomplished. Provision for pure water was necessary in villages and when good drinking water was provided 50 per cent. of the sanitation work was completed. They had to turn their attention to these two points,—the disposal of refuse on hollow ground and the provision of potable water. Great offenders as to excavations in the ground were the railway companies, and these hollows became veritable death traps in India. Most of such places in the mofussil became water-logged and were not approachable till February.

The third item was that scavengers were growing less and less obtainable in Guzerat. He thought Government should try to encourage this class of menial service by making them small grants of land in order to make them settle in different parts of Guzerat.

He advocated trained inspectors for the districts and the education of the people on the principles of sanitation and that there should be a full conservancy staff which would also clean wells periodically, and finally suggested that Government should contribute one anna per head of population for sanitary improvement.

Dr. D. H. Patel (Bombay) said that Dr. Turner in his able and practical paper referred to the habits and customs of the people of the country and compared them unfavourably with those of the English people. He very rightly said that Oriental habits were opposed to sanitation of the kind known in the West. Large masses were passively resistant to any sanitary method which was supposed to cause inconvenience. Ignorance was at the bottom of this. Yet, he could not understand how some of the advanced communities of India and even a fairly large number of the educated portions could allow their servants to throw household refuse out of the windows and into side passages or the streets. He was prepared to bear out Dr. Turner's statement on this point, nothing could be truer. It was impossible to condemn the habit too strongly particularly in the face of the facilities afforded in the shape of dust bins and carts to carry away such refuse. In endeavouring to improve the sanitary condition of the city two factors had always to be borne in mind. First the practice of all methods of modern sanitation as far as means and conditions permitted and second the education of the masses by the teaching of elementary hygiene. Much had been said on the first factor. He wished to explain the second factor. If they wanted the co-operation of the people in sanitary matters they must begin with the teaching of elementary hygiene in every school and in every class, and in all grades of examinations, be they university or otherwise; this subject should be made compulsory. Arrangements on a large scale for popular lectures on hygiene (personal and public) should be made. In conclusion he stated that unless there was hearty co-operation of the people sanitary progress if not nil would be tediously slow. In order to do this they must inspire confidence and this could not be done except by educating the masses in cleanliness and hygiene, in other words in the science and art of preventing diseases. This seemed to be one of the best and cheapest ways of fighting against scourges like malaria, plague, phthisis, &c., effectively.

Dr. K. M. Dubash, F.R.C.S., said that he wished to suggest that in addition to a pure water supply all sanitary measures should include the provision of a pure milk supply also. Even laymen now knew that milk was the carrier of many diseases and it was a cause, and a very strong cause, of the very high rate of mortality not only among adults but mainly amongst infants. This being so he thought the Congress should express its opinion that Government and the Municipalities should see their way to establish sterilized and humanised milk depôts as otherwise it was impossible to have an ideally pure milk supply.

THE DISINFECTION OF NATIVE HABITATIONS.

TO LIMIT THE SPREAD OF INFECTIOUS DISEASES.

By J. W. CORNWALL, M.A., M.D., D.P.H.,

Major, I.M.S.

In disinfection the immediate aim is to destroy the infecting germs of certain communicable diseases either before they have found entrance into the body as a measure of prophylaxis, or after they have escaped from the body to prevent them from gaining access to other hosts.

Before this purpose can be successfully accomplished, the life history of the particular organism to be dealt with, including both its intra and extra corporeal phases, must be known and at the same time the properties of the disinfectant to be employed must be clearly understood.

In practice there are few diseases in India in which disinfection, *i.e.*, the immediate destruction of the infecting germ by chemical or physical means, is possible; and none in which disinfection suffices without auxiliary sanitary measures.

* He agreed with Dr. Buchannan of Amraoti, that the natural enemy of the rat—the cat—should be extensively employed.

In this paper I shall concern myself with only the three principal infective diseases with which sanitary officers have to deal in India, namely, cholera, plague and small-pox. Disinfection on a large scale is seldom required for any others and that which applies to these three is likewise applicable with modifications to all the rest.

By far the greater amount of disinfection in this land has to be trusted for its execution to native officials who possess no knowledge but that comprised in the local instructions laid down for their guidance, and even that, it is regretted, is often not applied agreeably either to reason or to conscience.

The aim of medical officers of health must be, therefore, to simplify both theory and practice to the uttermost degree to allow room for as little error as possible in practice, while furnishing adequate reasons for all that is to be done, so that the disinfectors may go to work with understanding minds and be able to modify their procedure in right directions as circumstances may demand.

To act up to this principle it is evident in the first place that a disinfecting gang must be regularly trained if results which are worth anything are to be expected from their labours. It is not sufficient to give a few demonstrations to a failed matriculate and send him off with a cartload of chemicals to collect hands in any village he may go to for the performance of his ritual. Large sums of money have in the past been fruitlessly expended in wages and chemicals by expeditions of this nature.

We must make the most of the small amount of exact knowledge we have of the diseases above mentioned, but to go beyond it and to expend our forces in the realms of the unknown is to make an unjustifiable demand on the public purse.

In the case of small-pox disinfection is scarcely practised outside a few of the large municipal towns, and by no means universally in these. What do we know about small-pox and how far is disinfection calculated to prevent its spread? We know nothing of the causative agent of the disease beyond the fact that it is due to an organism placed with several others somewhere between bacteria and protozoa in a class named Chlamydozoa by Prowazek and Strongyloplasma by Lipschütz, having affinities with both groups but falling into line with neither. We do not know how the organism leaves the body except that the dried matter from the pustules is capable of transferring the disease if inoculated into the cutis of a susceptible individual, nor do we know what happens to it in the intervals between epidemics or why sporadic cases occur.

The accepted theory is that the disease is air-borne, * but to my mind there is little evidence to support this, and in my experience there is a great deal to be said against it. What good then can be expected from disinfection? The causative agent, whether air-borne or insect-borne, has been shown by the cumulative experience of ages to cling to the body, the clothes and the immediate surroundings of the patient and it can be rendered inert by many of the disinfecting agents at our disposal just as surely as vaccine lymph can, if similarly treated.

I hold, therefore, that apart from vaccination a considerable measure of safety can be secured to the inmates of a small-pox infected house, if not also to their neighbours, by the careful disinfection of the body of the patient and of every article of clothing which has been anywhere near him, the bed, bedding, furniture, floor and walls of all the rooms he may have occupied since the disease declared itself, together with any books or other articles he may have used.

It is here that the judgment of the person in charge of the disinfecting gang must be allowed play, and when the patient is only a tenant in a large house containing several families, he from his knowledge of their caste, position and customs must decide how far it is advisable to carry the disinfection outside the stricken tenant's quarters.

Passing to cholera we are on safer ground. We know that the infecting organism finds entrance through the mouth and leaves the body with the natural discharges. We can therefore secure safety by disinfecting and taking other steps to render innocuous all food and drink likely to have been contaminated, and at the same time taking precautions with regard to the discharges and all clothes, articles and places which may have been soiled by them. Disinfection need proceed no further, but even this much calls for the exercise of knowledge and discretion.

Coming to plague we touch the root of the whole matter as far as India is concerned. Prior to its outbreak disinfection was spasmodically practised by a few health officers. But little was generally known of either methods or material. So little that in the early days of plague, I had it on good authority, half a ton of calomel was purchased by a certain municipality in lieu of corrosive sublimate and a suspension of this drug in water was squirted into plague-infected houses.

Concerning plague we know that pneumonic patients cough and spit out immense numbers of virulent bacilli and that other persons can be directly infected thereby by inhalations or indirectly by means of soiled bedding and garments. We know that fleas can abstract plague bacilli with the blood they suck and can infect other animals subsequently and perhaps man also, and we know that plague bacilli can be inoculated directly into a wound. Some also maintain that the discharges are infective and that food and drink can become contaminated.

By the disinfection of soiled articles of apparel, bedding, furniture, floors and walls the destruction of adherent bacilli can be ensured, and by the use of a suitable pulicide errant fleas may be exterminated; discharges may also be rendered non-infective. Beyond this disinfection cannot help us. It does not come

* In this connection the experiments of Green (Journal of Hygiene, Vol. 8, No. 4, Sept. 1908) are of interest. He found that dried, powdered vaccine lymph withstood a temperature of 60° C. for 51 minutes, 37° C. for more than 20 days and 100° C. for 5 minutes, showing itself to be far more resistant to heat than lymph preserved in any liquid or semi-solid medium.

within the scope of this paper to discuss the utility of such measures as rat destruction, evacuation or destruction of habitations, I merely desire to indicate what we may expect to be able to effect by disinfection. In the matter of plague the judgment of the disinfecting officer is again called into play: in a large house he must decide what ought to be disinfected to secure the utmost benefit to the occupiers and what articles and parts of the house may safely be left alone.

Having cleared the way by explaining what we require of our disinfectants I will now shortly discuss the means themselves.

The ideal disinfectant is a very rapidly diffusible and penetrating gas which is incompatible with the life of micro-organisms and insects in high dilution with air and in a moment of time. Even were such an instrument available it would not be all sufficient.

We may at once put aside as impracticable in India disinfection by the action of all forms of gases or vapours, either generated in or pumped into a room, which have so far been employed to this end. The number of houses to which such a method could be successfully applied is so small even in large towns that the cost of the outlay could never be returned. Of liquid disinfectants not one in my opinion is so easily used, effective and cheap as either cyllin or izal, and these will operate on house interiors, discharges, clothing and, in fact, on anything which can come into contact with water without damage.

I have seen in actual use or described a variety of both ingenious and cumbrous contrivances for the application of liquid disinfectants but none is of such universal service as a collection of tubs, buckets and tin mugs.

Disinfection of clothes by boiling may occasionally be economical on a small scale, but can seldom be turned to account with advantage in practice.

Steam disinfection is only practicable at large centres, such as ports and railway detention camps, and then only touches clothes and bedding. Even for routine use in a Presidency town I found liquid disinfectants preferable.

Some reference must here be made to the routine disinfection of wells during times of cholera by potassium permanganate. This custom, I believe, is largely the outcome of the work of Mr. Hankin of Agra published some 14 years ago. Medical Officers all over the country have reported annually on the results following its use, mostly favourably, some few adversely, but these reports have been merely opinions substantiated by no acceptable evidence one way or the other. I have come to consider that the chief merit of the method is to keep people off the use of a certain well the contamination of which probability points to.

A single specific instance is within my experience in which there seemed to be some negative evidence on the subject. Cholera broke out in a small village which derived its sole water supply from 3 or 4 wells in the sand. These wells were rigorously treated with permanganate daily, the people continued to use the water, having no other, and cholera still spread. Good water was then brought daily in tank carts to the village and the inhabitants were convinced that the well water was dangerous. The epidemic promptly ceased and the tank cart supply was kept up for a month, after which the people were allowed to revert to the wells with no ill effect.

The question ought to be settled definitely, one way or the other, for it is a grave mistake to give people a sense of security if there is room for error and doubt in the minds of those who ought to know. It has been on my mind for a number of years to conduct some further experiments on this point, but a suitable opportunity has never offered itself. I think that a suggestion might well issue from this Congress that some Officer be deputed by Government to make the necessary investigations.

Disinfection and its practice has been a well worn subject of recent years and it is difficult to present any part of it in a new light. It can scarcely be considered apart from other sanitary measures and is of less importance than most. Nevertheless it has loomed largely in the eyes of the powers that be and a complexity that is not altogether its own has been imparted to it. Once the objects in view are known, and the working of the appliances at hand is understood, only ordinary judgment on the part of the disinfecting officer is required to enable him to direct the proper disinfection of any habitation, be it mat hut, mud hut, pukka building, chawl, tenement or palace. Without the available knowledge of the disease to be dealt with or of the action of the appliances provided, and lacking the intelligence necessary to adapt his means to circumstances, no disinfecting officer is likely to perform work of value.

It is the duty of the Medical Officer of Health of the town or district to keep himself in touch with the latest developments in the art of disinfection and to decide on the disinfectants which are to be used by his gangs. Knowing as I do that there is much money wasted by haphazard disinfection and often little good effected, I am of opinion that the more time and money spent on the education and maintenance of an intelligent band of disinfectors the better results will be obtained in the end, which signifies the saving of money by the efficacious application of a smaller quantity of disinfectant and the arrest of disease by the action of the preventive at the proper points.

In conclusion the matters to which I desire to invite the attention of this Congress are :—

(1) The desirability of teaching all persons employed in disinfection work the nature of the disease they are engaged to limit, of explaining the object of the measures they are required to take, and, in addition, of imparting to them a working knowledge of the properties of the disinfectants to be employed.

(2) The want of experimental data concerning the action of potassium permanganate in wells and reservoirs contaminated with cholera.

DISINFECTION OF INDIAN HOUSES.

By SORAB C. HORMUSJEE, M.D., D.P.H., M.R.C.S., L.R.C.P.,

Assistant to the Health Officer, Bombay Municipality.

At the outset I must express my deep appreciation of the kind consideration shown by the Committee of this Congress in inviting me to write this paper. The subject is no doubt of great importance, but I do not claim any originality or novelty in the views set forth in this paper. My main object will be to give an outline of the methods of disinfection in vogue in this City, and which of them are most effective, convenient, and economical.

Disinfectants are agents or substances employed to prevent the spread of contagious or infectious diseases. An ideal disinfectant should be a substance that will kill the germs which act injuriously on the higher forms of life, without having any marked action upon such higher forms. It should be, moreover, potent enough to destroy the spores of pathogenic organisms, which, as a rule, are more resistant than the germs which form them.

A knowledge of the value of disinfectants, and the use of some of the most valuable agents, can be traced to very remote times, and much of the Levitical law of cleansing as well as the origin of numerous religious ceremonials as practised in many of the ancient religions of the world, are clearly based on a perception of the value of disinfection. For instance, the burning of incense which is enjoined in the Zoroastrian religion tends to counteract the evil influences of all noxious odours, and embalming as practised by the Egyptians, is a good example of successful attempts to arrest putrefaction in very early ages.

The means of disinfection and the substances employed are very numerous, as are the classes and conditions of disease and contagion they are designed to meet. There are natural as well as artificial disinfectants.

Of the artificial disinfectants employed or available, three classes may be recognized :—1st, volatile or vaporizable substances which attack impurities in the air ; 2nd, chemical agents for acting on the diseased body or on the infectious discharges therefrom ; and 3rd, the physical agencies of heat and cold.

For the thorough disinfection of a sick room, the employment of all these three classes of disinfectants may be necessary, and we shall now consider a few of these agents which would be most suitable for Indian houses, after bearing in mind the class of diseases and their contagia that have to be commonly dealt with in this country.

As plague is the most important disease we have to contend with at present, I shall first deal with the various methods that have been employed for the disinfection of plague-infected houses.

The Indian Plague Commission, which was appointed in the year 1898, after carrying out certain experiments, came to the conclusion that an acid solution of Perchloride of Mercury of the strength of 1 in 1000, was a chemical disinfectant that was most likely to render efficient service in plague-infected houses.

The same Commission recommended that when employing this disinfecting agent, it should be made up in the form of a concentrated solution in acid, and issued in phials. When required for use, the solution should be mixed with water up to the required strength. To secure an accurate dilution, the wooden buckets in which the diluted solution is to be prepared, should be of such capacity as to hold just the quantity of water sufficient to dilute the measure of concentrated solution to the desired degree.

Before beginning the disinfection of a room by means of this chemical, all the household effects and such furniture as there may be, should be cleared out and placed in the open. The solution should then be poured freely over the floor and the walls should be vigorously brushed down with it by means of mops or brushes. It is also desirable to forcibly pump the solution into corners, crevices, rat-holes, and roofs which are otherwise difficult of access. After free application the room should be allowed to dry by opening all its doors and windows and also by opening the roof, by turning the tiles, so as to admit the rays of the sun into it. The disinfection of the furniture, clothing, bedding, etc., should then be proceeded with.

Infected clothing should be treated by being boiled in water in a caldron for half an hour and subjected to a temperature of between 60 and 100° C.; or it may be steeped in a neutral solution of Perchloride of Mercury or sent to a central disinfecting station to be subjected to saturated steam under pressure. Such fabrics as wool, silk, or leather, which would be injured or destroyed by boiling, chemicals, or steaming, and where no fumigation by means of formalin gas is available, should be spread out and exposed to the direct rays of the sun for 3 or 4 days. Small articles which may be of little value and which may have been grossly contaminated should be burnt.

All articles of furniture should be exposed to the sun and washed down with soap and water to remove grease and subsequently they should be treated with a free application of a 1 in 1000 solution of Mercuric Chloride. All copper and other utensils should be washed with a weak solution of Izal, Phenyl, or Carbolic Acid.

This, in short, was the method in vogue of disinfecting plague-infected houses in Bombay City and many other parts of India for a number of years. But within the last two years the researches of the Second Plague Commission, which were carried out at the Bombay Bacteriological Laboratory, and which have conclusively brought to light the fact that the plague is communicated to man from rats by means of rat-fleas, have

brought about a considerable alteration in the method of dealing with plague-infected houses.

This important discovery, *viz.*, that plague is communicated from rats to rats and from rats to man by means of the rat-flea, suggested the use of a pulicide, because we are now in a position to know that plague bacilli exist in nature either in the body of a plague-sick animal (chiefly the rat) or in the stomach of a rat-flea which has fed on such an animal.

Perchloride of Mercury, although it is a powerful bactericide, is not an insecticide. This was conclusively proved by placing guinea-pigs from which all fleas had been previously removed, in rooms which had been recently disinfected by means of this chemical. After a few hours, the bodies of these guinea-pigs were covered with fleas derived from these rooms. A recent laboratory experiment carried out by Captain Gloster, I.M.S., has also shown that fleas will emerge unscathed from an exposure of ten minutes in an acid solution of Corrosive Sublimate of such a powerful strength as 1 in 500. Moreover, it has been found by Dr. Marsh that the disinfecting action of this chemical is considerably neutralised on floors and walls saturated with organic matter, and specially in the case of the mud floors of native huts and houses which are smeared with cow-dung. In the light of these recent researches, therefore, regarding the manner in which plague is communicated, Perchloride of Mercury is useless as a disinfectant for plague-infected houses.

Since August 1906, Dr. Turner, Executive Health Officer, Bombay, introduced the use of pesterine as a disinfectant for houses infected with plague. The word pesterine is merely used for convenience of expression. This substance is Crude Petroleum (fuel oil) and is undoubtedly a powerful insecticide, as it instantly kills all fleas, bugs, and other insects that come in contact with it. Its method of application is very simple as it has to be brushed on the floors and walls of rooms to a height of about three feet. It is also a very cheap disinfectant as the cost of treating an average-sized room with it, comes to about ten annas. It is not, however, an elegant preparation and hence its use in better class houses is open to some objection.

The Director of the Bombay Bacteriological Laboratory has recently suggested the use of Kerosene oil emulsion for the disinfection of plague-infected houses. This emulsion is prepared by dissolving three parts of Sunlight Soap in fifteen parts of water by boiling. Warmed kerosene oil is then to be added to this soap solution gradually up to 100 parts. Finally, the oil and soap water should be mixed together by shaking or stirring the mixture.

Certain laboratory experiments which were carried out by Captain Gloster with this emulsion go to prove that fleas exposed to its action in a dilution of 1 in 1,000 for two minutes were almost always killed. A very badly infected godown was also rendered safe by its floor being washed out with a 1 in 20 dilution of this same emulsion, as was proved by the fact that a guinea-pig placed in this godown lived for days in it and remained well.

The same officer also recommends the use of Hydro-carbon emulsion which is prepared in a similar manner to kerosene oil emulsion, except that the hydro-carbon is not warmed. This substance is said to make a better emulsion than kerosene oil does, and besides it has some bactericidal power as well. It is however more inflammable and has a disagreeable odour.

Although as a rule the plague bacilli exist in the stomach of a rat-flea which has fed on an infected animal, it is by no means certain that they do not exist in other substances. For instance the excreta of sick animals or man also contain them. The second Plague Commission in one of their reports state that the plague bacilli when present in such excreta are as a rule rendered quickly harmless either by desiccation, or by the development and multiplication of saprophytic bacteria which are inimical to the existence of plague bacilli. The fact however of the existence of these bacilli in places, other than the stomach of the flea, necessitates the use of some disinfecting agent which has both pulicidal as well as bactericidal powers.

With this end in view, our Municipal Analyst, Dr. Ghadially, suggested in August 1907, the use of kerosene oil emulsion mixed with Cyanide of Mercury. The latter chemical is as powerful a germicide as Mercuric Chloride, and has the advantage of not being precipitated by albumen, gelatin, mucin, and organic matters, and can therefore be usefully employed on mud floors smeared with cowdung. Dr. Ghadially suggests that Cyanide of Mercury added to the kerosene oil emulsion in sufficient quantity to make its strength 1 in 50, would be an ideal disinfectant for plague infected houses.

It is perfectly reasonable to suppose that such a disinfectant possessing the combined properties of an insecticide as well as a germicide, would not only be valuable in cases of Plague, but also in Cholera and Typhoid fever cases, when we bear in mind the important part which flies play in the propagation of the two latter diseases. A disinfectant of this nature would keep off flies and prevent their breeding and at the same time kill the germs of these two diseases.

In Hongkong, equal parts of Cyllin and Petrol, diluted with water to 1 in 200, has been used for the disinfection of plague-infected houses. It acts both as a germicide and a pulicide. The solution has to be freshly mixed each day as it undergoes certain chemical changes, the nature of which has not yet been worked out.

In an earlier part of this paper I have stated that it has now been proved that plague bacilli exist in nature either in the body of a plague-sick animal such as the rat, or in the stomach of a rat-flea which has fed on such an animal. The most successful disinfectant therefore would be such as is capable of destroying both rats and their fleas. The fact that rats and fleas are generally to be found in situations inaccessible to the application of the disinfectants mentioned above materially handicaps the use of these substances. It therefore

stands to reason that a gaseous disinfectant which is alike poisonous to rats and fleas, and which is capable of penetrating into the inaccessible places frequented by those creatures, is the only one which offers some hope of success in combating this disease.

Professor W. J. Simpson in his Treatise on Plague very strongly advocates the use of the Clayton gas or Sulphur-polyoxide for this purpose. He states with great confidence and assurance that the newest and best method of disinfecting a house infected with plague is to fumigate it with Clayton's apparatus. The advantage of this machine is found in a mechanical device which forces the gas into the room to be disinfected and so brings about a greater concentration and diffusion of the disinfectant than has ever before been accomplished.

This Clayton gas is of a complex nature and consists mainly of Sulphurous Acid (SO^2), Sulphuric Anhydride (SO^3), and other higher Sulphur Oxides. It is claimed for this gas that it is poisonous alike to rats and insects, and its main advantage is that it will bring about the disinfection of every article in the house or room, *in situ*, and its employment therefore saves the necessity of having a central station for steam disinfection, and of removing clothes, bedding, etc., to this central station.

In order to describe the method of disinfection by means of this Clayton apparatus, I cannot do better than quote the words of Dr. W. J. Simpson :—

"One pound of sulphur is used for every 400 cubic feet of space to be disinfected. The apparatus having been brought to the front or back of the house and the few preliminaries carried out, such as the sealing of the chimneys and outlets of the house, the opening of the drawers and boxes and cup-boards, which can be done by one of the household, the covering over with cloths or paper any stuffs or material of delicate colours, and the opening up of floors in the neighbourhood of rat runs, every thing is ready for disinfection. As exposure to the gas, of wine, fruit, and flour in open bottles, tins, or vessels will injure these articles, they should either be removed or sealed up in close vessels. The pipes and branch pipes are then fixed and put into the house wherever required, and the gas is pumped into the house and maintained at a saturation of 12 per cent. for 8 to 12 hours, or all night, with the result that everything living, whether rats, insects, or the plague bacillus will be destroyed. The windows are then opened in order to thoroughly ventilate the rooms, and after a few hours the house can be entered and dead rats and insects removed, after which the rooms are ready for occupation with safety."

Dr. Simpson further advocates that in order to prevent the escape of plague infected rats it is advisable to fill the houses abutting on the infected house with the Polyoxide before commencing with the infected house.

For the successful disinfection of a house by means of this method it is necessary to make it gas tight. This is not always possible in the case of the majority of chawls and houses in this country. Then the gas has to be maintained at a certain percentage of concentration for several hours otherwise it will not kill rats and fleas. It takes a very long time to effectually disinfect a room by this method, and therefore it is impracticable when the plague epidemic is at its height in any City or town. It will be necessary to have several sets of this machine to cope with the work when many plague cases and deaths are occurring in a City.

A matter which requires to be specially noted, when attempts are made to destroy fleas by means of a poisonous gas such as this one, is that the floors of many Indian houses are made of earth. These insects can easily bury themselves beneath loose earth or sand and can in this way escape the full poisonous effects of the gas. From certain experiments that were recently carried out at the Bombay Bacteriological Laboratory with this Clayton gas, it would appear that "rats can be killed with it when they are confined in an open room, but if they are allowed to move about freely in the room some may escape before the concentration of the gas in the room becomes strong enough to overpower them. Moreover, when the rats are afforded shelter in certain types of burrows they may not be killed by the gas. The experiments also show that it is comparatively difficult to kill fleas by means of Clayton gas, especially when they are found on earthen floors."

From the above description it will be seen that this method of disinfection is not suited to the majority of Indian houses, and it is apparently not so efficacious as some of its advocates claim it to be.

The ordinary sulphur fumigation, although it was held in high repute in the 16th and 17th centuries, and has been regarded as an antidote against the plague since the time of Hippocrates, has been found to be very uncertain in its action and mostly useless for plague-infected houses. This method of disinfection has been carried out in Bombay houses along with Perchloride of Mercury, but it has been given up for a long time in favour of pesterine disinfection. Sulphur is still however the official disinfectant in many European countries and, if fumigation by its means is properly carried out in an air-tight room, there is no reason why it should not prove efficacious in cases of Small-pox, Cholera and Relapsing fever.

No description about gaseous disinfectants would be complete without a reference to Formaldehyde gas. The germicidal action of this gas has been clearly demonstrated and a large number of devices for applying this disinfectant have been suggested. My esteemed colleague, Dr. B. K. Goldsmith, informs me that one of the best apparatuses that he has seen for the elimination of this gas, is the one known as the Lingner's Disinfecting Apparatus.

The greatest merit of this apparatus is the absolute reliability of its working and the certainty with which all pathogenic germs are destroyed. It is very economical to use, and time is also economised, as the whole of the disinfecting fluid can be sprayed into a room 3,500 cubic feet in capacity, in half an hour. Owing to this rapidity of discharge of the disinfecting vapour it is unnecessary to go to the considerable trouble of stopping up every crevice in the room to prevent loss of

the vapour. This is a point of considerable importance in many Indian houses where it is impossible to render a room perfectly air-tight.

The following is a short description of the apparatus. There is a central receiver which is charged with the disinfecting fluid. Surrounding this is a ring boiler which contains water, and is heated by means of methylated spirit contained in a heating ring. When the water in the ring boiler begins to boil, the steam passes through a pipe into the central receiver and the pipes carry the combined steam and Formaldehyde in the form of a fine spray through four nozzles out into the room. This very fine spray fills the room in a remarkably short space of time, and owing to the pressure under which it is developed it penetrates into the crevices otherwise left untouched. The apparatus has a folding tripod with it which serves to raise it from the floor.

This apparatus was used in Astrachan during the last epidemic of plague in that town, and it is stated in the Journal of the Russian Society for the Protection of National Health that some 315 rooms and their contents were disinfected by means of this apparatus, and it was found unnecessary to undertake any further disinfection owing to the complete extinction of the disease.

The bacteriological tests with the apparatus have also proved satisfactory in the highest degree. Professor Klein has shown that it destroys anthrax spores and tubercle bacilli in dried sputum, while the continental workers have found the Formaldehyde generated in this apparatus to have a satisfactory penetrating effect. Cultures exposed under such test objects as the pocket of a dressing gown and in a small depth of a hair cushion were rendered sterile. Dr. Goldsmith informs me that cultures of anthrax, tubercle, and a few other bacilli were placed in different parts of a room, experimented on in Manchester, some under cover and at different altitudes. All these cultures were rendered sterile in a few hours. They were prepared and subsequently examined by Professor Delepine, Director of the Public Health Laboratory at Manchester.

To my mind disinfection by means of this apparatus is eminently suited to better class houses in India. It is likely to be very effective in Plague, Tubercle, Smallpox, Enteric Fever and Cholera cases.

Amongst liquid disinfectants I would like to make special mention of Izal. The ordinary Izal fluid of commerce is an exceptionally powerful germicide for bacilli of the Coli-typhoid group. Thus Klein found that a solution of 1 in 500 completely disinfected typhoid stools in 15 minutes, and a similar solution of 1 in 600 rendered typhoid urine aseptic in five minutes.

The bulk of the infection of Phthisis is communicated in the home and the workroom. During the lifetime of a phthisical patient it is necessary to take measures to minimise the risk of infection to others from this disease, the more so when such a patient shares a single room in a crowded chawl with others. In such cases, a systematic disinfection of the rooms occupied by such patients is required at least once a week.

At the Congress of Hygiene which was held at Glasgow in the year 1904 a paper was read by Drs. H. Kenwood and F. J. Allan on the practical disinfection of rooms and workshops occupied by sufferers from consumption, in which they strongly advocate the use of Izal. It is claimed for this disinfectant that it is eminently suited for a room in which a phthisis case exists, because it is non-poisonous, it gives of an odour which is not irritating to the sensitive breathing organs of the sufferers, it does not injure textile articles to which it is applied, and its germicidal properties are not lessened even after prolonged exposure. The method of employing it is to use a solution of 1 in 50 for sputum, and 1 in 100 for rooms and for wet dusting. This method of disinfection of Indian houses where consumptive patients live, is very desirable, and might, with advantage, be carried out.

Izal has also been employed for the prevention of infection in Enteric fever. In the *Practitioner* for August 1908, Dr. Knyett Gordon recommends the use of Medical Izal oil internally. By the use of this drug the patients' excreta cease to be a source of danger in the spread of Enteric fever.

DISCUSSION.

Mr. T. S. Ramchandrier followed with his contribution "Effects of Izal and Heat on Fleas," and prefaced it by saying that the experience of Madras might be useful in regard to the appointment of Sanitary Officers. There the Sanitary Officers were appointed and controlled by the Sanitary Commissioner and the Municipality paid their salaries. The Corporators he found did not agree with their Health Officers.

Dr. Cook had just seen his last days of India owing to the personal dislike taken to him by some of the Corporators. The whole machinery in this respect was very heavy. He was surprised at Major Clemesha's suggestion of Health Inspectors on Rs. 25 to 30 per month, such a low salary offered to a qualified man while an ignorant motor driver got twice as much salary.

EFFECTS OF IZAL AND HEAT DISINFECTION ON FLEAS.

By Hony. Asst. Surgeon P. S. RAMCHANDRIER.

Disinfection of plague-infected houses in the State of Mysore is done by two methods, one by chemicals and the second by heat.

Of the chemicals, Hydragyri perchloride 1 in 1,000 was in use since the appearance of plague in 1898. Izal was substituted from 16th May, 1904, or thereabouts, as per order of the Senior Surgeon and Sanitary Commissioner with the Government of Mysore.

The subjoined table shows the number of houses disinfected for three years by the two methods :—

Year.	Plague-infected Houses.			Houses where suspicious cases of fever occurred.			Adjoining houses, houses with infected rats and other causes.		
	Heat.	Izal.	Total.	Heat.	Izal.	Total.	Heat.	Izal.	Total.
1904-05..	292	472	764	138	264	402	591	815	1,406
1905-06..	233	143	376	161	41	202	634	203	837
1906-07..	233	180	413	69	157	226	475	740	1,215
Total ..	758	795	1,553	368	462	830	1,700	1,758	3,458

Since the finding of the Plague Commission of 1905-07 that Loemopsylla Cheopis plays an important part in the spread of plague, any disinfectant which is being used must be directed to kill them. It may also be said that the experiments conducted to test the efficacy of any disinfectant must imitate, as far as possible, natural conditions. Whatever conclusions Dr. M. Wynter Blyth, B.A. (Cantab.), B.Sc. (Lond.), F.I.C., might have arrived at from his Laboratory experiments, such may not stand the test in practical methods.* To avoid such an error the following experiments were conducted in such rooms as are usually being occupied by the poorer classes in these parts. Two rooms in the compound of the Epidemic Disease Hospital in Bangalore were taken up for conducting these experiments.

For purposes of description, the rooms may be marked as 1 and 2.

Room 1.

This is a room in an isolated building used as the residential quarter. The room measures $10' \times 8' \times 12'$ paved with burnt slabs and roofed with pot tiles. It resembles one of those of the middle class. The walls are plastered, but there are crevices.

Room 2.

This is a room, opposite to the above, used as servants' quarters. The floor is of mud, broken up and loose in many places. The walls are of the same materials but white-washed. There are several small crevices in the wall. The roof is of Mangalore tiles. Except in the matter of tiles, the room exactly corresponds to one of those inhabited by the poor class people. The floor was being daily washed with a solution of cow-dung.

The details of the Experiments conducted in these rooms are as follows :—

Experiment 1.

On *18th June*, 1907.—13 rat fleas collected from healthy rats brought from the city for dissection were put into room No. 1. The doors and windows were closed. The chinks in the doors were plastered with mud.

19th June, 1907.—The room was thoroughly disinfected with 1 in 100 Izal lotion. The doors and windows were left open for the room to dry.

20th June, 1907.—4 Guinea-pigs were left in the room to run about. After 48 hours the Guinea-pigs were chloroformed and searched for fleas. None found.

Experiment 2.

Seventy-three healthy rat fleas were put into room No. 1. Two Guinea-pigs were allowed to run about. After 24 hours the Guinea-pigs were searched for fleas. 5 were found on them which were returned into the room. 25 more fleas were added, making the output of fleas 98. The two pigs were again left in. Also 2 rats in two cages, and a mouse in a third cage were kept.

28th June, 1907.—All were examined. 14 fleas were caught on the Guinea-pigs, 7 on the rats, and none on the mouse.

All the fleas were put back into the room. The room was disinfected with Izal lotion 1 in 100. The doors and windows were thrown open for 24 hours.

29th June, 1907.—Two Guinea-pigs were allowed to run about the room, the doors and windows being closed.

1st July, 1907.—The Guinea-pigs were examined and no fleas were found on them.

Experiment 3.

1st July, 1907.—Forty-four fleas and two Guinea-pigs were put into the room.

2nd July, 1907.—The Guinea-pigs were examined. 11 fleas were found on them. The Guinea-pigs were removed but the fleas were put back, adding 71 more fleas at the same time.

The room was then disinfected with Izal 1 in 100.

3rd July, 1907.—The floor of the room was quite wet owing to rain during previous night, and a leak in the roof.

4th July, 1907.—The floor being dry, two Guinea-pigs were allowed to run about.

6th July 1907.—The Guinea-pigs were examined. On one of them one flea was found.

Experiment 4.

This and the next one were conducted in room No. 2.

6th July, 1907.—11 fleas were put in with two Guinea-pigs.

9th July, 1907.—121 fleas were added.

10th July, 1907.—The Guinea-pigs were searched under chloroform. 18 fleas were found on them. The fleas were put back into the room, and the Guinea-pigs were removed.

In the evening, the room was disinfected with Izal lotion 1 in 100 and left open.

11th July, 1907.—Two Guinea-pigs were left in the room.

12th July, 1907.—The pigs were examined and two fleas were found.

Experiment 5.

12th July, 1907.—84 fleas were put into the room with two pigs.

13th July, 1907.—91 fleas were added.

* "*The Indian Medical Gazette*," March, 1908, pp. 92-94.

14th July, 1907.—The Guinea-pigs were examined. 27 fleas were found on them.

The room was first swept and the sweepings were removed. Then it was disinfected with Izal lotion 1 in 100.

15th July, 1907.—Two Guinea-pigs were let into the room.

16th July, 1907.—These were examined and one flea on each was found.

Summary.—Three experiments were conducted in the room similar to that found in the houses of the middle class. In the last experiment, fleas were still alive after disinfection. In the two experiments conducted in the room similar to the poor man's, fleas were alive after thorough disinfection with Izal.

Conclusion.—Izal disinfection 1 in 100 does not completely kill the fleas in houses with mud walls and floors.

Heat Disinfection.

The following experiments were conducted in room 2:—

Healthy fleas were put into the room and two Guinea-pigs were allowed to run about for one or two days. These were searched under chloroform and the fleas on them counted. These fleas were put back into the room and the Guinea-pigs isolated. The room was then disinfected by heat in the following manner. A number of "bratties" or cowdung cakes were piled up in several places and ignited, thus raising the temperature of the room to more than 60°C—a paraffin thermometer being kept at a height of 6ft. or above, to see if the temperature had risen to the melting point of the paraffin. Two Guinea-pigs were allowed to run about the room after it had cooled, and 24 hours after or thereabouts searched for fleas under chloroform.

Experiment 1.

From *6th September*, 1907, to *9th September*, 1907, 160 fleas were put into the room with two Guinea-pigs.

10th September, 1907.—Examined the Guinea-pigs under chloroform and found 21 fleas. Put back the fleas, and removed the pigs. Disinfected with heat.

12th September, 1907.—Put in two Guinea-pigs to run about.

15th September, 1907.—Examined the Guinea-pigs. Found 9 fleas on them.

Experiment 2.

From *15th September*, 1907, to *17th September*, 1907, put into the room 208 fleas with two Guinea-pigs.

19th September, 1907.—Examined the pigs and found 11 fleas on them. Disinfected the room with 5 heaps of bratties $1\frac{1}{2}'$ by $2'$ each. The paraffin Thermometer was kept 6 feet from the floor. It melted.

20th September, 1907.—Put in two Guinea-pigs to run about.

21st September, 1907.—Examined them and found 14 fleas on the Guinea-pigs.

Summary.—The two experiments conducted with heat disinfection as is generally carried out in the Bangalore City go to show that fleas are not killed at 60° C.

Remarks.—The above experiments are of great importance considering the reliance placed on these methods of disinfections and the amount of money spent on them.

THE LENGTH OF LIFE OF FLEAS.

Preamble.—With a view to find out how long rat fleas (Loemopsylla cheopis) could survive without their natural food, a number of experiments were conducted by me, the results of which are placed here. In these experiments, the fleas were placed in different materials, and the period they lived in such was ascertained, as will be seen from the following table.

Experiment number.	Date of the experiment.	Material in which the fleas were placed.	Number of days the fleas survived.
1	23rd June 1907.	In a plain test tube ...	5 days.
2	3rd July 1907.	In a test tube with rat hair.	7 ,,
3	4th July 1907.	Do. ...	6 ,,
4	5th July 1907.	In a plain test tube ...	4 ,,
5	20th Aug. 1907.	In a test tube with fresh cow-dung.	9 ,,
6	21st Aug. 1907.	Do. ...	8 ,,
7	24th Aug. 1907.	In a test tube with rat hair.	5 ,,
8	26th Aug. 1907.	In a plain tube ...	4 ,,
9	30th Sept. 1907.	In a large wide-mouthed bottle with earth and cow-dung moistened with cow's urine.	17 ,,
	Do. ...	Do. ...	18 ,,

In the above series, 3 experiments were conducted in plain tubes with no material whatever, and the fleas in them did not live longer than 5 days. With rat hair, the longest period has been 7 days: with moisture, cow-dung, and earth, the longest has been 18 days. In similar experiments conducted by the Plague Research Commission in India, it was concluded that "in the absence of their natural food, they were unable to live for a fortnight." The period now found out by the above experiments is 4 days longer than what was ascertained by the Commission.

Conclusion.—In native houses, where cow-dung with water is daily used for the floors, the chances of fleas, infected and healthy, living for a long period, is possible.

Reference :—Journal of Hygiene, Vol. 8, No. 2, page 238.

DISCUSSION.

Dr. P. A. Dalal, L. M. & S., said that in reference to disinfection by formalin vapour Dr. S. C. Hormusji did not recognise the importance of a peculiar property of the gas and that was the property of changing into the polymeride paraform on coming into contact with any substance, be it wood or glass or clothing. Hence proper penetration was not obtained and thorough disinfection was next to impossible, unless the gas was generated under pressure, but this of course involved an expense. In order to obviate this McLaughlan of New York recommended the addition to formalin of 25 per cent. of liquified carbolic acid. It was found then that the polymerisation did not occur. No special apparatus was required for disinfecting a room, a sheet only being required, which was dipped in the mixture of formalin 75 parts and phenol 25 parts, and hung in a closed room for twelve hours. Only eight ounces of the mixture was sufficient to thoroughly disinfect a room one thousand cubic feet in capacity.

Dr. Ezekiel asked what system was adopted in heating a room for disinfection ?

Dr. Ramchandrier explained that it was done with dry cow-dung cake and a thermometer was set and when it went to 60° centigrade it was considered enough.

Dr. A. G. Newell said that disinfection was badly carried out in India as a rule from the ignorance of those who carried it out and such methods brought both disinfection and the disinfectants into disrepute. It was highly desirable that methods of desinfection should be properly taught beforehand to those to whom the work was to be entrusted, and more regard should be paid to the character of the disinfectant and its suitability to the purpose to which it is to be applied. Much money was wasted daily owing to disinfectants being used which were useless for the actual purpose for which they were employed. In the example given by Major Cornwall, he thought, the calomel used by mistake for corrosive sublimate probably did as much good as if the sublimate had been used. To use sublimate solution on floors of native huts and in drains where the solution was likely to meet with much organic matter was simply to throw away public money. He did not agree with Major Cornwall that there was little evidence to support the air-borne theory of the spread of small-pox. He considered the facts mentioned by him as evidence in favour of the air-borne theory. If he disbelieved in this theory then why did he advocate disinfection as he did. If the clothes were infectious as he admitted how could they be infectious except through the medium of the air. The occurence of sporadic cases was no evidence against the ærial theory. Its analogy to other infectious diseases supported the air-borne theory. Plague was a bad example to prove anything about disinfection. Disinfection in pneumonic cases of plague should be thought to be of value if applied to disinfection of the sputum and fœces. He was surprised that Major Cornwall did not think this important. If plague was transmitted by fleas he did not see any good could be done in bubonic cases by disinfecting the furniture and walls. What was wanted in such cases ? segregation and a pulicide. Diffusible disinfection gases were useless in native houses and in most other houses in India. For the best class of houses formaldehyde should do. He agreed that a liquid disinfectant appeared to offer the best solution for general disinfection in India. More information was required regarding most disinfectants under the very varying conditions met with in India. Though he had used potash permanganate in Cholera outbreaks for disinfection of water with success apparently due to this disinfectant, he had however noted, in the literature of the subject, doubt expressed as to its value. He was disposed to think that such doubt was the result of cases continuing from other possible sources of contamination or so-called cholera, being cases of rice poisoning. The point should be definitely settled by cholera germs in water being tested with different strengths of potash permanganate.

Dr. J. A. Turner said that they all knew the valuable assistance Section IV had from Dr. Sorab Nariman, M. D., D. P. H., Honorary Secretary and Dr. P. H. Dalal, his Assistant ; the organisation they had carried out and the onerous duties they had performed were beyond any praise which he could bestow, and he felt sure the members of that Section would gladly support the proposition which he had much pleasure in proposing. " That the best thanks of those, who represented Section IV, are due to the Honorary Secretary, Dr. Sorab K. Nariman, and the Assistant Honorary Secretary, Dr. P. A. Dalal, for the indefatigable manner in which they had discharged their onerous duties in connection with this most important Section."

Dr. N. N. Katrak seconded the proposition which was carried unanimously.

Dr. N. N. Katrak then proposed the following resolution :— " That the best thanks of the representatives of Section IV of the Bombay Medical Congress of 1909 are due to the Vice-Presidents, Lieut.-Colonels Crimmin and Dyson and Dr. J. A. Turner, for having presided over the prolonged sittings of this Section from day to day with such ability and conspicuous success."

Dr. B. S. Shroff seconded the resolution which was carried *nem con.*

Dr. J. A. Turner, who presided, thanked the members who had submitted such interesting papers as had been read at the meeting and also those who had taken part in the various discussions in connection with Section IV of the Bombay Medical Congress of 1909, and the proceedings of the Section terminated.

SECTION V.

OPHTHALMIC SURGERY, VESICAL AND RENAL CALCULI AND MISCELLANEOUS PAPERS ON TROPICAL SURGERY.

Sectional President.

Surgeon-General H. W. Stevenson, I.M.S., Surgeon-General with the Government of Bombay.

Vice-Presidents.

Colonel T. E. L. Bate, C.I.E., I.M.S., Inspector-General of Civil Hospitals, Punjab.

Colonel P. A. Weir, M.B., I.M.S., Inspector-General of Civil Hospitals, Central Provinces and Berar.

Major Ashton Street, M.B., F.R.C.S.

Major Henry Smith, M.B. I.M.S.

Major P. P. Kilkelley, M.B., I.M.S.

Secretary and Sectional Editor.

Dr. S. H. Modi, F.R.C.S., M.R.C.P.

Assistant Secretary.

Dr. R. B. Billimoria, B.A., L.M. & S.

Introductory Address.

Surgeon-General H. W. Stevenson, I.M.S., President, in opening the Section, said :—

" Of all the branches of medical science the one which most appeals to the peoples among whom our work lies is Surgery. In medicine they have, like the peoples of all countries in the world, their own ideas, and as many of us know, often think little of Western modes of practice. In the domain of Surgery, however, this is not so, and

they will place the most absolute trust and confidence in the skill of the Western surgeons. It is the boast of the Service to which I have the honour to belong that this confidence is well deserved, and in the different lines of tropical surgery we have many names to which we can point with pride as those of men eminent in our art. Keegan and Freyer in the surgical affections of the urinary tract, Charles in Elephantiasis, and at the present time Smith in that of Ophthalmic surgery are names which will always be connected with brilliant and original work.

"In selecting these names I have no desire to seem to neglect the work done by the large body of men who in this and other tropical countries steadily, day by day, relieve thousands from distressing bodily conditions and save many lives by their honest and successful operative work. It is to them that the confidence of the people to which I have referred is due, and I think they have their reward in the assurance that by their own personal skill and knowledge they have saved the life of a man, or relieved him from some distressing condition which rendered life a misery to him. The object of this Congress is that by meeting here we may learn the ideas of our brother surgeons and by comparing them with our own we may possibly increase our knowledge of how to help those who need our aid."

THE TREATMENT OF

TRACHOMA PANNUS AND CORNEAL ULCER DEPENDING ON TRACHOMA.

By Major HENRY SMITH, I.M.S.,

Civil Surgeon, Jullunder, Punjab.

I assume that every one is familiar with the naked eye pathology of these conditions as well as with their clinical history.

Trachoma.—The treatment of trachoma is in this country of exceeding importance. I have no doubt but that trachoma causes more blindness in Northern India than all other eauses put together. It is the great cause in Northern India of pannus and eorneal ulcer with their consequences. Triehiasis apart from entropion is no more common in India than in Europe.

Prophylaxis.—These cases should be treated as eontagious, though their infective capacity is not of the very acute or certain nature of the infection of gonorrhœal ophthalmia.

Early in my career I was an orthodox follower in the treatment of these conditions. My experience as a follower was very far from satisfactory. To cure trachoma such as we see in Northern India in two or three years did not satisfy me. It meant too great a drag on my time—neither did it satisfy the patient, his patience was not up to sueh prolonged and painful treatment. In short, if we cannot cure a patient of his trachoma in from 7 to 14 days he comes to the conclusion that we are not going to suceeed and we lose sight of him in consequence. It may be thought that a man who puts himself absolutely at our disposal is uncivilised if he wont attend us daily for 12 months for a pain-giving application to his conjunctiva for the cure of trachoma: I am afraid if I were in his position I would be considered uneivilised for the same reason.

After a liberal trial of all the standard remedies for trachoma I have gravitated to the use of nitrate of silver as the only drug; and in certain eases with exuberant granulations to scraping them with a knife so as to clean the cartilage and then painting the affeeted area with nitrate of silver.

Red oxide of mercury ointment I tried and gradually inereased its strength up to 40 grains to the ounee whieh I found gave no more ineonvenience than the stereotyped 8 grains to the ounce, but even in this strength I found it was not satisfactory as regards results.

My method is as follows:—evert the lids, eoeainize them with a 10 per eent. solution of coeaine, scrape the whole affected area with a knife when the condition is intense, if not intense I do not scrape it. After scraping, and in those cases which I do not need to scrape, I paint the surface with 60 grains to the ounce nitrate of silver solution which I neutralise with any chloride solution as soon as it has properly whitened the affected surface. Onee every second day is sufficiently often to apply this strong solution of nitrate of silver. I commenced with weaker solutions, and, not satisfied with the results I gradually increased its strength up to 60 grains, whieh I found to be the maximum which would not produce such reaction as might affect the cornea. A few sueh applieations is enough for the worst of cases. The patient after this treatment would be the better oceasionally of 1 and 1/2 grains of opium as the reaction always causes some pain and often a good deal. In most eases sponging with either hot or cold water relieves him sufficiently of this after-inconvenience.

These eyes should never be bound up, dressing up eyes for many eonditions only eauses the retention of objectionable matter in the conjunctival sac. I never hesitate to ineise the external eanthus if there is objectionable spasm.

Nitrate of silver thus used is neither more nor less than a caustic which destroys a certain depth of tissue. It has the great advantage over sulphate of copper, carbolic acid, sublimate, &c., in the fact that it is not so painful and in the fact that it is not deliquescent and thus does not spread over an area which we do not wish affected by it. It has the great advantage over all other medicinal agents used in that we can stop its action instantly with a chloride solution when it has done as much as we wish. The actual cautery is, compared with nitrate of silver for such purposes, a barbarous weapon. Who can control the action of a red hot iron when he wishes to destroy a trifling depth of tissue?

Pannus.—I have tried peritomy, the red hot iron and the cauterization of a strip of circumcorneal conjunctiva with solid nitrate of silver, and of these I much prefer the last.

When I commenced the use of cyanide of mercury subconjunctivally for fundus conditions I came to the conclusion that the œdema of the conjunctiva which it produced, lasting a week, resembling the œdema which jequirity ideally applied produces, followed by fixing down of the conjunctiva to the sclerotic, might be of use in pannus. I tried it for this condition and have now given up all other methods. 15—20 minims of 1 in 4,000 cyanide of mercury solution injected beneath the conjunctiva balloons it up all round the cornea. Immediately the whole ocular conjunctiva becomes œdematous and the corneal margin is overhung with chemosis and the tissues of the eyelids also suffer from œdema very like the effects of jequirity ideally applied. At the end of a week the œdema subsides and if the case has not been severe the pannus will have disappeared leaving the conjunctiva fixed to the sclera. This fixing soon gives way to its normal mobility. In pannus the circumcorneal conjunctiva is much more mobile than normal and its mobility extends to a varying degree over the cernea as is well seen when it is ballooned up on a subconjunctival injection. If the case is a bad one the patient may require a second injection to clear it up and the second one should be done on the sixth or seventh day, before the conjunctiva becomes fixed down.

These subconjunctival injections cause considerable pain; the conjunctiva should be anæsthetised with a few drops of 10 per cent. cocaine solution before the injection and the patient should get $1\frac{1}{2}$ grains of opium after it. The pain lasts about three hours and disappears as soon as the œdema sets in properly.

To the uninitiated, the eye seems in a dangerous condition from all this chemosis and œdema, but I have never seen anything go wrong from it. The cornea remains uninjured and the effect is to very markedly clear up its haziness especially that of the circumferential parts of it. In the treatment of diseases of the eye I do not know anything more marked than the effects of cyanide of mercury thus applied for pannus.

Corneal Ulcers, the results of granular ophthalmia and from other causes.

In my observation the first thing of importance in the treatment of corneal ulcers is to avoid bandaging up the affected eye. Bandaging it up retains matter of a deleterious nature in the conjunctival sac. Instead of bandaging up the eye the outer canthus should be cut to relieve the eye from the pressure caused by spasm when it exists as it almost always exists. This not only controls the spasm but allows a freer outlet for the secretions. This incision heals up after a few days—fully as quickly as we wish. The next thing of importance is to avoid the use of atropine, eserine, and cocaine if possible. Cocaine is only used to relieve pain—opium internally is the drug for this purpose. Cocaine is objectionable in that it always seems to exaggerate the inflammatory condition. Eserine there is never any object in using unless the very questionable one of reducing intraocular tension, and assuming that it does not do so—about which I have some doubt—it is objectionable in placing the pupil in such a position that it may be occluded if perforation takes place.

In the treatment of corneal ulcers I am convinced that atropine is the most misused drug in the pharmacopœia. It always intensifies the corneal inflammation and the trachoma on which the ulcer depends and it undoubtedly increases the intraocular tension and on both counts it does much more harm than good. True, it dilates the pupil but of how much service is that? If a perforation does not occur it is not needed, if a perforation does occur nature's splint, the iris, is better than none. If the iris becomes adherent to the perforation it shuts off the anterior chamber with remarkable quickness and perfection. If through the influence of atropine, there is no iris in place to shut off the anterior chamber we have evidently upset nature's method and done harm. If taphyloma of the iris results it should be snipped off when the ulcer has healed and an iridectomy done in the most suitable position later on.

It has been a repeated experience with me to get cases that have been using atropine or atropine and cocaine along with other things and to observe that they have been going rapidly from bad to worse and when these remedies are stopped and the ulcers simply touched with 40 to 60 grains to the ounce of nitrate of silver on a small swab to notice the improvement in 24 hours. I douche them with 1 in 2,000 sublimate solution from a tank giving six feet of pressure and then touch them with 60 grains to the ounce silver nitrate and immediately neutralise it. Drops unless they are put in with the eye exposed with a speculum are the nearest approach to useless, they are so diluted before they reach the affected part that they have neither meaning nor efficiency. I never hesitate to cut the outer canthus to relieve spams and remove the consequent pressure and allow the secretions free exit. I give the patient an effective shade, and opium if necessary to relieve pain. I am disposed to think that peroxide of hydrogen used as I used silver nitrate would be equally effective and I intend to give it a liberal trial;

the effect of nascent oxygen on the healing of ulcers elsewhere should be equally good in the case of the eye.

The use of subconjunctival injections of 1 in 4,000 cyanide of mercury I have tried and have never seen harm from it but often good. I think the good effect is in part due to the cushion of œdematous conjunctiva it causes all round, which serves as a protection to the ulcerated surface from the pressure of the lids, thus securing rest for the affected surface. In phlyctenular ulcers it has a remarkable effect. In them I balloon up the conjunctiva on cyanide solution, scrape the ulcer floating on the top thereof and touch it with the end of a silver nitrate stick and I have seldom seen this one sitting procedure fail to clear up the circumcorneal phlyctenular ulcers.

Swanzy recommends tapping the anterior chamber through the floor of the ulcer to relieve tension: when a perforation is certain to follow, tapping of the anterior chamber is undoubtedly useful, but I think most surgeons would prefer to tap through a healthy portion of the sclero-cornea than through a diseased surface—a procedure which would be certain to be followed by the iris, if not previously against the wound, becoming promptly attached to it.

Of course I throughout imply that the cause of the ulcers and pannus will not be neglected.

DISCUSSION.

Major Kilkelley, I. M. S., remarked that he could not agree with Major Smith regarding the use of atropine in corneal ulcers. It is often misused undoubtedly, but there are cases where it is quite essential; for example, in a case which he recently came across, where the iritic adhesions would never have occurred had atropine been used. In cases of doubt, he suggested homatropine in place of atropine.

Capt. Gidney, I. M. S., said that atropine was indicated if the ulcer was central. Atropine has the disadvantage of causing conjunctivitis, resembling Trachoma. It is not a drug for universal use, but reserved for selected cases only, and then with great care. As regards pannus, he was always successful by the "scraping" method. Mercury-cyanide would act just like jequirity, and thus be a severe tax on the already inflamed conjunctiva. For pain, he would prefer cocaine to opium, as the former acts directly on the local part.

Dr. Prabhaker said that atropine *is* essential in certain cases, *e.g.*, when the ulcer goes deep. Cocaine is dangerous in cases of corneal ulcers. As Major Smith has been so successful with Cyanide of Mercury and strong solution of Silver Nitrate, I would like to try it, though it seems a heroic method. As regards pannus, as the cause of it is Trachoma, it is this latter which requires treatment, and he had seen the treatment giving excellent results except in very chronic cases.

Dr. J. Rutter Williamson, M.D. (Poona), remarked that he had found H_2O_2 of considerable value in corneal ulcers in lessening the discharge and decreasing the pain. Dionin grs. 40 to 60 to an ounce as ointment or drops had proved useful in the later stages for clearing up the corneal opacities left after ulceration.

Dr. W. Wanless, M.D. (Miraj), suggested the use of copper sulphate in glycerine for Trachoma, as it does not decompose like the aqueous solution, and thus can be given to the patient for use at home, as he cannot afford to keep them in the Hospital for a long period The formula suggested was grs. X to XX to an ounce, of which the patient takes a few drops and dilutes with water before use.

Reply by Major Smith.—With regard to Major Kilkelley remarks what I have said I did not intend to be construed as absolute. There are certain cases though very few in which a mydriatic is useful, I agree with Major Kilkelley in preferring Homatropine for those. Dr. Rutter Williamson's experience of per-oxide of hydrogen is interesting.

In answer to questions. The treatment I advocate cures a case of pannus in roughly from one to three weeks according to the severity.

Asked if I preferred mercury cyanide to jequirity preparations I say yes. The mercury cyanide acts with certainty and with uniformity and we know exactly what to expect, with jequirity preparations the reverse of this is the case.

SOME NOTES AND OBSERVATIONS ON THE

OPERATION OF THE EXTRACTION OF CATARACT IN THE LENTICULAR CAPSULE,

BASED UPON THREE YEARS' EXPERIENCE OF THE OPERATIONS AT SMITH'S CLINIQUE AT JULLUNDER IN THE PUNJAB.

BY CAPT. W. E. McKECHNIE, M.B., CH.B.,

Indian Medical Service, Jullunder, Punjab.

Smith, of Jullundur, has brought the operation of extraction of cataract in the capsule to a very high pitch of excellence. His experience now embraces nearly 20,000 cases; such an experience of an operation, I venture to say, has hitherto been unparalleled in the history of ophthalmic surgery. And it is all the more remarkable in that it is the experience of only one decade. Smith began practising the operation as a routine in 1899.

The enormous number of patients who come to Smith to be operated on for cataract affords, to my mind, a reliable index as to the value of the operation. Granted that cataract is very common, comparatively speaking, in the Punjab, this fact will not account for the great number of operations done by Smith in a year, amounting as they do to over 2,000 No other operator in the Punjab or elsewhere can show figures anything like as large: nor can it be explained on the ground of want

of skill in the ordinary operation on the part of the other surgeons in the Punjab. There are and have been operators of great skill in this Province. Colonel Perry has been Professor of Surgery at the capital of the Province for 25 years and has enjoyed a great reputation amongst the people as a surgeon. I have myself seen him do the ordinary operation for cataract, and it could not have been better done.

Smith did not begin to take a phenomenal place as a busy operator till, having worked out the lines of the operation in a satisfactory manner, he adopted extraction in the capsule as his routine procedure. The result is that Jullunder is the Mecca of sufferers from cataract.

Smith has no extraneous advantages. Jullunder is one of the smaller and poorer townships, or rather villages, of a poor country. It is on a single line of railway with the mountain wastes of the Himalayas to the north-east and the deserts of Sind to the west. On the railway to the north are the important centres of Lahore and Amritsar : whilst to the south is Delhi, once the capital of India. Were patients from a distance in search of important centres they would stop at these places and not leave the train at Jullunder.

The hospital is small and poorly equipped, being only intended for local needs. It falls so far short of the standard we are accustomed to in Europe as to be hardly conceivable by a European surgeon. The buildings he might think were those of a farm. The staff he would find to consist of Smith himself assisted by the following natives : an assistant surgeon, a hospital assistant, and a few dressers. The staff, in fact, is not as large as that of one ward of the Edinburgh Royal Infirmary, whilst the number of patients at one time under treatment in the hospital for major operations on the eye is frequently as large as 450.

These facts are important because they indicate that the immediate results of the operation must be good. Were many of the patients to require attention daily, or even as seldom as twice a week, the organisation would break down ; the 'staff' would be paralysed by overwork.

As a matter of fact, the cataract cases are operated upon as soon as they come to hospital in the morning. There is no preliminary treatment. There are two tables in the operating room, and while one patient is being operated on, another is being bandaged up and carried away. The great majority of them are not dressed again till the eighth day, and receive their discharge on that day. Thus there is a minimum of dressing.

The assistant surgeon on his daily rounds finds out any case suffering from indications of post-operative complication and attends to him.

The dieting is the simple food of the people sold to the patients and their friends who look after them by a man from the bazaar. The very poor get a ticket entitling them to get food at the hospital expense. Only about 3 per cent. get free diet. All the nursing is done by the friends of the patients.

The fact, then, that under such conditions, these same patients and their friends, having left the hospital, are so satisfied with the result that they in their turn send their friends to the same place in such astonishing numbers, shows, to my mind, that the operation is emphatically a good one, and that its after-results are better than those hitherto attained by any other operator in the Punjab. And when I say any other operator in the Punjab I might just as well say any other operator in the world, for I do not think that operators on cataract are anywhere else more experienced.

In view of these facts any *a priori* reasoning designed to show that the after-results of the operation must be bad may be disregarded ; and the gloomy prognostications are, moreover, disproved by the excellent after-results which have been noted by myself and others in patients operated on by Smith from one to six years previously. The usual appearance is that of a clear black pupil and a brilliant eye ; and vision with correcting glasses is usually 6/6.

Smith's fame amongst these poor and ignorant people extends a long way. At his hospital I have seen Afghans from Cabul, men from the sea-coast of Karachi, from the wilds of the Himalayas, the desert plains of Sind, and the more fertile regions of the Ganges. And this fame has all been attained by a knowledge of how to use a couple of blunt hooks in the extraction of cataract.

Again, it is interesting to note that there is no selection of cases. Indeed a European surgeon might well be appalled by the unfavourable condition of many of the eyes operated upon. And there is no doubt, did circumstances permit, that many of the cases would receive preliminary treatment if it could be given to them. But for several reasons, in Smith's practice such treatment cannot be given.

Eyes which offer any hope of vision are operated on, having regard to the principle that some vision is better than none at all. The following classes of eyes are operated upon ;—

Eyes with old trachoma and blepharitis ; glaucomatous eyes ; eyes whose lenses have been couched and have a consequent atrophy of the retina and night blindness ; eyes with iris adherent to the lens ; and eyes in every stage of cataractous degeneration from the first hazy beginnings to complete atrophy, always assuming that the retinal condition indicates function sufficient to admit of improvement of vision when the lens is removed. If both eyes are cataractous, both are done at the same sitting.

Combining these unfavourable conditions with the great popularity of the operation there follows but one conclusion and that is, that in Smith's hands it is an eminently sound one and the operation of choice.

If we grant this it comes to be a question whether it is Smith and he alone who can do the operation. The operation would not be of much use to the progress of the surgical art if only one man could do it. And I may here state without preamble that there is no jugglery about it. It would be hopeless for the ordinary man to attempt to imitate a Leoncavallo. None may aspire to play billiards like Roberts ; to sing like a Caruso or a DeRetzke ; to play the violin like Pagannini ; or to

walk the tight-rope with the assurance of Blondin. But Smith's performance is comparable to none of these. It does not require a special genius. What Smith can do others may do also, provided they are properly taught and can get a sufficient amount of practice. The ordinary man cannot hope to quite attain Smith's skill because he will not be able to get so much practice or experience as Smith has had. But with an experience of about two hundred operations he will attain sufficient skill for practical purposes. A beginner must have good manual dexterity, as any one professing to be an ophthalmic surgeon should have; and he should be taught how to do the operation in actual practice by one who can do it well himself.

I am speaking from personal experience, because I have been taught to do the operation by Smith himself, who has kindly allowed me to do over 500 operations under his personal supervision, and who has taught me every detail to be learned in the manipulation of the various kinds of eyes. I have attended Smith's clinique during the last three years.

Prior to this I had occasionally attempted the operation, but with indifferent success, as I did not know how to do it. The first extraction in the capsule I ever saw done was done by myself, or rather by the patient. It was one of my early operations, and was intended to be done in the usual way with capsulotomy. When I had made the incision, probably none too skilfully, the patient, an old woman, powerfully screwed up her eye and delivered the lens neatly upon her cheek. There was no prolapse of iris nor escape of vitreous; the pupil was round and small and central and jet black. The wound healed rapidly and without any complication, and the result was what one might call ideal.

Pleased with this first extraction in the capsule I endeavoured to repeat the performance. Sometimes I was successful, but rather oftener I think I made a hash of it. I either burst the capsule or I had to do a capsulotomy to avoid using what I considered to be unjustifiable force; or I lost vitreous and had to shut up the eye without enquiring too closely into the position of the iris.

When, three years ago, I first saw Smith operate, I realised that I had not known how to do the operation. I watched Smith operating for a long time and studied his methods as closely as I could. But when I went back to my own hospital and tried to do the operation I found somewhat to my disappointment and astonishment that I was not much better at it than I was before. When I saw Smith doing it, it all seemed simple and easy. When I tried it myself all sorts of distressing things used to happen.

An accomplished rider of the *haute ecole* will make his horse do all manner of things, such as cantering on three legs, without the means by which he does it being very visible to the spectator. The uninitiated might imagine that the horse was performing its evolutions of its own accord. And anyhow it appears to him as if he could ride the horse quite easily and probably make it do a lot of its tricks himself. The best way to disillusion such a one is to mount him on the horse. The erstwhile docile and obedient animal may very likely turn into a lion rampant. So with Smith's operation. Seeming simple in the hands of an expert, it may be exceedingly difficult if not impossible in the hands of the uninitiated, who is not aware of, or who does not practise, all the little aids which make the operation simple and successful.

I used to watch lens after lens being extracted, entire in its capsule, smooth and glistening: some mature and ripe, some half ripe, others only just beginning to be opaque, and a few the dense black cataracts; some with big and some with small nuclei, some hard and thin, others round and soft and fat. Out they came and into the bottle, lens after lens, without a hitch.

Then Smith began to teach me by allowing me to operate myself under his direction. It is the only way to learn; and I shall always rest under a deep debt of gratidude to Smith for his kindness in teaching me, and for the pains he has taken to render me proficient.

The first thing of which I became aware was that it was much easier to operate in Smith's hospital than in my own. The reason was that the assistant knew exactly what to do. The first lesson, then, is that the assistant is almost as important as the operator. Next I found that there was something to learn at almost every stage of the operation. There were many little things which I had failed to notice despite the large number of times I had seen Smith doing the operation. These little things are important in that they conduce to a smooth and even operation without complications and distractions, and hence lead to a good result.

Smith's technique is such that it may be said to avoid all complications, and in this lies the secret of its success. The eye is quickly and gently dealt with, and it shows its gratitude by its good behaviour both at the time of the operation and afterwards.

I have now done over 500 extractions in the capsule as a pupil of Smith's. Smith has also taught three other surgeons. The two whom I know and I myself can do the operation with ease and confidence and an almost uniform success. Of the other operator, Knapp of America, I cannot speak from personal knowledge.

The operation, then, can be done by others besides Smith; and the failure of those ophthalmic surgeons who have tried to do the operation and have not met with success is due to their faults of technique and not to the fault of the operation. There is a great deal to learn as to *how* to do the operation and I can fully endorse Smith's claim that he has evolved the technique of the operation.

As regards the assistant, in his case also a certain amount of practice is required before he can do the work efficiently. His chief duty is the holding of the eye-lid retractor. Simple as this duty may seem it is not so simple as it looks; and it took me several weeks of daily practice at operations before I became really good at it. The holding of the eye-lid properly is of the very greatest importance as on it depends the safety of the operation.

Such then is an account of Smith and his operation. I speak from personal observation and experience of Smith's practice at Jullundur during the last three years: and Smith has very kindly allowed me to do about 500

extractions in the capsule on his patients, and has thoroughly taught me how to do it. Having been put in the right way by a master, I have had a very gratifying success, and a relative immunity from disaster or complications. My own cases, unlike Smith's, have been more or less selected ones, as Smith himself has always done the cases where there was glaucoma or a previous dislocation of the lens. Of late I have done all other kinds of cases.

One of my early cases was lost from suppuration; both eyes were lost. I attribute this to want of skill causing me to soil the instruments on the patient's lids or other parts. In a second case I failed to extract the lens. During the extraction the vitreous presented and I let go too suddenly. The lens, which was half out, fell back plump into the vitreous and I could not get it out again. I have had no serious escape of vitreous: and my total percentage of escape of vitreous is about 6 per cent. The only drawback which I have noted from this complication is that owing to the toilet of the wound being interfered with the iris has rather frequently been caught in the wound in these cases. With the above exceptions my results have been good, and much better than I could have hoped to attain by any other operation.

I wish to absolutely endorse what Smith says as to the advantages of his operation; and I would lay it down that—except in patients under 25 years of age—it is the best operation for nearly all cataracts; and that it is the operation of election in immature cataract; and that the time of election for the performance of the operation of cataract extraction is when the cataract is immature, because then the operation of extraction of cataract in the capsule is easiest to perform and is then least likely to be fraught with complications either immediate or remote.

The general acceptance of such a doctrine will mean a very great change in the present methods of treating cataract; and it will mark a very great advance.

EXTRACTION OF CATARACT IN THE CAPSULE.

By H. GIDNEY, F.R.C.S.E., D.P.H. (Camb.), Capt., I.M.S.,

Civil Surgeon, Dhubri.

When I was honoured with an invitation to read a paper before this Congress I had little hesitation in selecting a subject, my only fear is that I might not be able to do adequate justice to it. It occurred to me that more interest would be aroused amongst us and more benefit derived in a method of surgical treatment that concerns itself with our every-day work in India, than if I had chosen some other subject which, though of special importance to ophthalmologists, would seldom fall under the personal care of a general surgeon. In India the treatment of cataract is of more importance than any other branch of surgery, for it forms about $\frac{1}{3}$ of the total selected surgical operations performed, and the number of extractions average about 20,000 annually. It is for this reason that I would ask your attention whilst I endeavour to place before you my experience and views on the Intracapsular Extraction of Cataract.

Since the main difference between this operation and the ordinary combined capsule-laceration is the treatment afforded to the capsule, the subject under discussion might aptly be called "The Battle of the Capsule," for the omission of one step, the opening of the capsule, constitutes the chief point over which various forces have been waging a scientific war for many years in the columns of *The Indian Medical Gazette*. The combatants so engaged and who represent most of the leading eye men in India might suitably be divided into three parties; (*a*) those in favour, (*b*) those against, and (*c*) those who advocate Intra-Capsular Extraction in a few selected and suitable types of cataract. Before I proceed it would not be amiss to state that in this important and practical operation it is unfair to either condemn or advocate it on a meagre experience, for during the first 50 or 100 extractions one is under training and has much to learn. The idiom *Abusus non tollit usum* might well be applied here, for the pendulum of opinion which swings first in one particular direction and after a time in another, requires very careful watching; we should not be too much impressed with one swing and allow it to claim our entire attention, lest in so doing we strain a point in its favour and utterly ignore the other swing. The pendulum of the capsular clock has swayed in both directions, the Intra-capsular and the Capsule-laceration, and has done so ever since Pagenstecher first advocated extraction in the capsule as a routine measure. The Intra-capsular swing was at the onset a very weak one, for it found favour with few ophthalmic surgeons, and extraction with laceration became recognised as the orthodox manner of treating cataract. It is only recently that Major H. Smith, I.M.S., of Jullunder, has revived it and given us the benefit of his unrivalled experience, with the result, that to-day the ophthalmic world is looking to the East and watching with great interest the splendid work done by Smith. That this swing is now a strong one is evidenced from Smith's numerous followers not only in the Service, but also amongst the number of ophthalmic surgeons from Europe, America, and the colonies who have visited and are visiting Jullunder; in fact, speaking as a mofussil Civil Surgeon, it is often the topic of discussion when we meet; the question being "What do you think of Smith's operation?" It has occurred to me, and I feel sure you will agree, that a sufficient period has elapsed and that the time has arrived when we should come to some definite conclusions as to which is the better of these

two operations. The time for such conjectural assumptions and expressions, based on "old established facts" and a meagre number of operations, as such-and-such a complication is "sure to happen"; "there is every likelihood of it happening"; "it is bound to happen"; "there is a dread of it happening," or "there is a deep-rooted aversion," &c., &c., has long passed; they are meaningless and unscientific, unless substantiated with accurate ophthalmological proofs, and cannot be accepted as determining factors in the settlement of this important subject. Something much more definite is not only needed in the interests of science, but is demanded from us by the younger generation of eye-men. I am conscious of the difficulties we in India labour under as regards the ultimate results of our operations, we cannot follow up our cases years after extraction as is done by our more fortunate colleagues in Europe; but what we lose in this respect we gain in having more operative experience and are in a position to more or less look upon our first few hundred extractions as the initiary stage of our cataract experience. Up to now those in India who condemn extraction in the capsule have received little or no help from their European colleagues, who are in a better position to bring forward carefully compiled statistics, showing exactly how far certain complications, such as vitreous escape, or Retinal Detachment, militate against the final result of this operation; in fact, judging from the absence of any mention of extraction in the capsule in some of the recent text books, it would appear as if such an operation did not *exist*. It is for this reason I assert that the "fall" or "stand" of extraction in the capsule, which is admittedly the more brilliant of the two, depends and "*must*" be judged on practical results, and by this I mean, results obtained in the same manner as is applied to the capsulotomy operation. As an illustration let me take vitreous escape:—The Capsule-laceration advocates contend that the evil consequences arising from such a complication are as a rule not immediate but remote and take months or years to develop. This is based almost entirely on experience and "old established dread" of European surgeons, who are better qualified to express an exact opinion, being able to follow up their cases. This being so, and considering the great revival which extraction in the capsule has recently exhibited, why, I ask, has no one come forward with a recent extensive series of such cases. There has been no lack of time and material for this to have been done. Possibly they experience some of the difficulties that we labour under; in any case, are we not justified, judging from the enormous literature bearing on this point, in accusing impaction in the incision of capsular tags and retained lens cortex as the causes of remote deterioration of vision following a Capsule-laceration extraction? Might not the same analogy be drawn in the development of an abdominal Hernia, years after a laparotomy has been performed, and, in connecting the one as the result of the other, adduce it as a drawback to the original operation? If we are to judge, much as this is desirable, the merits or demerits of every surgical operation years after its performance, more especially cataract which is a senile change and distinctly a disease of the aged, there would be very few, and in this category I include capsule-laceration, that would stand the test and come out of the scrutiny with credit, when compared with immediate results. Although I give in to none in respect and gratitude to my old teachers, yet if I am correct in interpreting their apparent silent attitude on extraction in the capsule to mean that they would rather we fought this vexed question out amongst ourselves in India, the home of cataract, the same as was done with Litholoplaxy, then, I maintain with Smith, that we should unhesitatingly subject all "old established facts and dreads" which have already enjoyed too long an analytical immunity, and new ones too, to a more recent and up-to-date rigorous scrutiny, one which modern science and riper experience demand. Some of these were facts at one time when the manipulative dexterity of cataract extraction was confined to a few, and when conjuntival asepsis was in its infancy and barely appreciated; but, in common with all other branches of surgery, times have changed, ideas have altered, operative technique is now perfect and widely possessed, and conjunctival asepsis, though not perfect, is almost so. Viewed and judged in this light, I am so certain of the way in which the tide of opinion will flow, that I feel justified in prognosticating a marked revival of extraction in the capsule, and, although its superiority over Capsule laceration, which Smith compares to that of Litholoplaxy over Lithotomy has been jeered at, yet I say the day is not far distant when it will be recognised, not as an exaggeration or arrogance on his part, but more than the truth, and that the splendid work done by Smith will more than entitle his name to be enrolled in such distinguished company as Freyer and Keegan.

Before enumerating and discussing the advantages and disadvantages, I would like it to be distinctly understood that I do not consider extraction in the capsule a panacea for all forms of cataract; there are limitations to its application, and in these cases I am equally strong in advocating the capsule-laceration operation. I hold that it is contra-indicated in congenital, and the cataracts of adolescents; when there is plus tension; in the semi-gelatinous variety of senile cataract, when the cornea is abnormally small; when there are posterior synechiae which refuse to break down under moderate pressure; and in some "*very*" rare cases of abnormally large lenses.

In discussing this subject I find it convenient to divide operators into two distinct schools; (*a*) the "Intra-capsular," (*b*) the "Capsule-laceration." These schools are peculiarly divided in India, *viz*., the "Intra-capsular" led by Major Smith, includes besides Birdwood, Oxley, and myself many other eye surgeons whose experience will be welcomed at this Congress. The Capsule-laceration School is led at present by two Presidency eye surgeons, Col. Maynard and Major Elliott, also Col. Herbert.

The Intra-capsular School. The advantages claimed are:—(1) A cataract can be extracted at any stage of its maturity; (2) its superiority over all other operative procedures in the extraction of immature cataract; (3) unless the capsule bursts, which it seldom does,

especially if a selection be made, the entire lens in its capsule is extracted; (4) the comparative marked absence of Iritis as an after complication; (5) the absence of need for a secondary decision operation; (6) absence of the train of post-operative inflammatory symptoms so closely connected with and mainly caused by retained cortex; (7) absence of impaction in the incision of capsular tags, and its adhesion to the Iris, with its subsequent dangers; (8) fewer instruments are introduced, thereby reducing the chances of infection, and the ill effects of over-free instrumentation; (9) convalescence is markedly shortened; (10) increased degree of visual acuity with a higher percentage of good vision, *i. e.*, between 6/6 and 6/36 more especially 6/6 results; (11) atropine is unnecessary in the after treatment; (12) lower percentage of striped Keratitis; (13) it is in all respects an infinitely superior operation.

"*The Capsule-laceration School.*"—The following are the disadvantages they bring forward against extraction in the capsule, *viz.*:—

(1) Frequent loss of vitreous with its immediate and ultimate dangers, *e.g.*, (*a*) Impairment of vision, (*b*) Infective inflammations, (*c*) Retinal detachment, (*d*) Hæmorrhage, (*e*) Delayed union, (*f*) Prolonged lowering of tension, (*g*) Distorted pupil.

(2) That by so frequently rupturing the supporting diaphragm, consisting of the Suspensory Ligament, the posterior parts of the lens capsule, and the Hyaloid membrane, which acts as a guard against the inroad of infection and a safeguard to the anatomical equilibrium of the eye, we *ipso-facto* surrender the integrity of the organ.

(3) The operation violates the essential conservatism of correct surgery, in so much that it introduces an unnecessary risk, for the sake of advantages which can be otherwise more safely and equally obtained.

(4) Frequent rupture of the capsule with its bad effect on vision.

(5) Incarceration and prolapse of Iris.

(6) Haziness of the cornea.

(7) The necessity of unjustifiable pressure to extract the lens in the capsule with its dangers.

(8) Prolonged irritability, redness, lachrymation, and chemosis.

(9) Higher degree of post-operative Astigmatism.

(10) It is not an operation to be recommended for beginners.

(11) The difficulty in attending to the toilette of the incision, lest the Hyaloid be ruptured, and of its impossibility when vitreous has escaped.

(12) That what is gained on the one hand, by extracting in the capsule, is probably more than lost on the other hand, by the increased frequency of vitreous escape with all its dangers. These points might well be considered under two groups (*a*) the important and (*b*) the unimportant, I shall confine myself to the former and discuss each in turn.

Advantages.—Its suitability for Immature cataract is being widely recognised even by capsule-laceration operators. Maynard, page 107 "Manual of Ophthalmic Operations," now admits this. I would refer you to a recent paper on this subject read by Smith before the American Opthalmic Congress, and to one I have submitted to be read, next April, at the Naples International Ophthalmological Congress, in which I have dealt exhaustively with the matter. Briefly, its superiority over artificial maturation, is the dangers and uncertainty of the latter procedure, and extraction with capsulotomy is not only very unsatisfactory, owing to its many complications, but incomplete, on account of the intractable variety of after cataract which invariably results. As Maynard says "The risks of expression are worth running to avoid such complications" or as Smith so correctly sums it up "Ripening procedures are either dangerous or disappointing and the surgeon would be better advised to either wait on Nature's ripening process, or extract immature cataract in the capsule," and I agree with them. My own experience of over one hundred such extractions, has convinced me that it is the "*ideal*" operation; the capsule rarely bursts, being as it were stronger, and very slight pressure is necessary for extraction. The results obtained, and worked out on Jessop's classification, are given in table A.

TABLE A.

Variety of operation.	Vitreous escape %.	Capsule burst.	Capsule left behind.	Septic infection	Iritis.	Visual results.		
						Success.	Partial success.	Failures.
Extraction in the capsule (Immature cataracts.)	6	5	3	...	3	91	8	1

Bursting of the capsule.—It is unquestionable that when a cataract is extracted in its entire capsule no better result can be obtained; there is no need for further anxiety on the part of the surgeon, or patient, regarding a subsequent discission, which is not uncommonly required after a capsule-laceration. This is one of its most conspicuous advantages. Given a normal healing, unaccompanied with sequelæ, the result is as near perfect as is possible, and can be but rarely approached by the capsule-laceration operation. in fact 6/6 vision, or very nearly so, is practically assured.

Rupture of the capsule varies in frequency from 5 to 17 per cent. according to the experience and skill of the operator. It can be markedly reduced by a proper selection of cases, execution of a large sized incision, avoidance of haste; and manipulative gentleness and care. It is least likely to happen with Immature and Hypermature cataracts, and more frequently in a large sized lens with a small cornea; congenital, and cataract of adolescents; the semi-gelatinous, or blue coloured variety of senile cataract, and when there are posterior synechiae.

When it bursts, the worst that often happens, is a conversion into an ordinary capsule-laceration operation, but it even now claims advantage of its own, because as this accident mostly occurs when the lens appears at the point of coming out, it can, in at least half the cases, be extracted in its entirety, by dissecting forceps, and the result is as good as if it had not ruptured. If we fail to extract the capsule, the consequences are likely to be serious, for it is now in places loosened from its attachment to the Suspensory Ligament, and being but imperfectly opened as compared with a well executed capsulotomy, the greater part of it together with a varying amount of cortical debris is left in the eye, forming an intractable variety of after-cataract. This disadvantage is neither minimised nor denied by us, but on the other hand one must remember the numerous cases in which the capsule is extracted entire. I have performed a discission on eleven of my cases, with a visual improvement in ten. I have at times observed that the upper part of the capsule tends to be displaced backwards towards the vitreous, showing a small clear area above it, a discission in these cases is likely to produce vitreous opacities, owing to its free admixture with lens cortex ; this happened in one of my cases. A more serious condition is when with a ruptured capsule, there is an escape of vitreous, resulting at times in poor vision. Our opponents make the most of this complication, but I would point out that a similar condition is produced in a capsulotomy operation accompanied with a vitreous escape ; and what holds true for one must be the same for the other ; on closer investigation it will be found, that with experienced operators, this drawback is almost equally common to both operations ; take Smith's capsule bursting as 8 per cent. with capsule left behind in 4 per cent. and even if vitreous escaped in each of these 4 per cent. cases, we have a condition which is no worse than what happened in a capsulotomy operation, where the average vitreous escapes is 4 per cent.

Iritis.—That Iritis is markedly absent after this operation few will deny ; this must be so because the chief cause of this complication is got rid of, *viz.*, "cortex." This is admitted by some of our opponents and, though they make "little" of it, they are very decided in their opinions as to the part played by cortex. On the other hand Elliott holds a different view, and draws a marked distinction between "*Irritation*" of the Iris, which is commonly observed after a laceration extraction, "*Iritis*" which is uncommon ; the latter he considers to be a pathological condition. He holds that the connection between the retention of Cortex and Iritis does not exist to the extent that we believe it to do. To obtain a clear understanding on this point it is desirable to take a review of what both Schools say. Pagenstecher considered the prevention of Iritis as one of the greatest advantages of Intra-capsular extraction and this is more than corroborated by Smith who reports two cases in 2,494 extractions in unbroken capsule, whereas, during the same period, he had 5 per cent. in 263 extractions in which the capsule either ruptured or was left behind. My own results, which include Iritis of all grades of severity, are 3 per cent. in the Intra-capsular, which mostly occurred when the capsule ruptured, and 14 per cent. in the laceration-operation. If this is not conclusive evidence of cortical debris as the cause of most cases of post-operative Iritis, I should like to know what is Macnamara says that the more experience he has, the more convinced is he that most of our failures are due to retention of lens debris and capsule. Herbert, in commenting on the absence of clear active pupils the day after laceration extractions, holds that the exudations he observed, were mainly due to irritation from particles of lens substance left behind, and this he says is proved by the almost sure absence of Iritis after extraction in the capsule and the capsulotomy extraction of Morgagnian cataracts ; he also attributes his exemption from occluded pupils, not so much to guarding the wound from infection, as to a vigorous after treatment of Mercury and Atropine. Maynard, in admitting the comparative absence of Iritis in Intra-capsular extraction, says that a slight degree of Iritis is fairly common after a capsulotomy operation and that retained capsule and cortex are liable to set up Iritis by irritation apparently. Smith says that Iritis does not follow when the lens is extracted in its capsule, and, when present, is due to retained lens matter and capsule ; he draws no distinction between "Irritation" of the Iris and "Iritis," but calls them both Iritis, and I agree with him. Elliott on the other hand, in drawing a distinction between irritation of the Iris and Iritis, holds, that most of the cases which we call Iritis, and which he says are characterised with a plastic exudate, are no more to be considered as inflammatory in nature than the aseptic healing of any wound by first intention. The determining factor, he says, is sepsis, and, in its absence, we are unjustified in calling the condition an inflammation, clinically speaking. Although he admits that to leave cortex is undesirable, yet he holds that it is incorrect to throw on it the whole responsibility of post-operative Iritis. Now if retained cortical matter is not the cause of Iritis, or let me call it Irritation of the Iris with a plastic exudate, and if it is merely the result of the traumatism inflicted on the Iris by the Iridectomy and which is performed in both operations, why is this exudate absent in an Intra-capsular extraction ; why is it not found after the performance of an optical Iridectomy, and why is it more frequent in Intra-capsular extractions when the capsule ruptures ? I maintain that this is overwhelming evidence that the main cause is retained lens matter. The capsulotomy operators may say what they like of the benignness of most cases of simple Iritis when properly treated, and, in so doing, attempt to minimise its risk ; they may divide post-operative Iritis into as many varieties as they choose, such as Irritation of the Iris, non-infective Iritis, infective Iritis, &c., but they cannot get over the fact that the practical difference between a mild attack of what they call "Plastic Iritis" and a well marked case of Irido-cyclitis or Panophthalmitis is only a question of degree in the one, and an additional entrance of septic organisms in the other ; that it is but a step from those exudates classed as non-inflammatory, to those mainly lymphoid in character, and yet another step from

this to complete occlusion of the pupil with a discolored atrophic Iris, indicating total posterior synechiæ, and a gluing together of all the structures, in which the vitreous is sure to participate and vision is reduced to moving objects only. Although the part played by sepsis cannot be denied in the severer forms of Iritis, yet do not these grades of severity form the links of a chain of post-operative inflammations, each so closely connected with the other, that we can never be sure where they begin, or where they will end? I do not assert that all, or many cases of Iritis end disastrously, but I do most strongly maintain, that, whereas by extracting in the capsule we practically eliminate Iritis, we more or less invite and court its appearance and development in the capsule-laceration operation, for I have little doubt that most of the muddy pupils and exudates so frequently observed 24 hours after its performance are mainly due to the baneful and irritating action of lens debris; in fact we supply a pabulum for the entrance and propagation of both pathogenic and non-pathogenic organisms; add to this the additional strain thrown upon the absorptive powers of the eye and we have a condition which further handicaps the tissues of the organ in their struggle with micro-organisms. They may make "little" of this complication, as one easily counteracted by Atropine and Mercury, followed if necessary in ten or 12 days with a discission operation, which they say, if properly safeguarded, is devoid of risk, but this surely stands as a confession of a weak spot in the operation; moreover what does the patient think of this even temporary impaired vision, with its discomforts, shattered hopes, prolonged medication and stay in Hospital? I ask; what is there to commend itself in an operation, characterised in the majority of cases with a plastic exudate, which, if not speedily treated, is likely to develop troublesome symptoms; and if these are averted, there can be no two opinions that convalescence is retarded, and is not always uneventful, that the adhesions formed result in a pupil possessed of a limited degree of activity. Why talk of one as an irritation of the Iris and the other as Iritis due to sepsis? Iritis can be produced by irritation, trauma, septic infection, and other causes. Why count the percentage of Iritis only on those cases which develop Iridocyclitis and other severe grades of inflammatory reactions which are, practically speaking, the final results of untreated exudates? All grades should be included. Why not, in the face of such strong evidence, give the credit of this advantage to the Intra-capsular operation and admit that it constitutes a bugbear of the first magnitude in capsule laceration? In any case the fact still remains that the operation which eliminates Iritis from its list of complications, however benign it may be, is "undoubtedly" the more superior one.

The absence of need for a secondary discission operation:—That this is another of its conspicuous advantages, not even its most adverse critics will deny, for the entire capsule is got rid of "*once and for ever.*" In a small percentage of cases, when the capsule ruptures and is left behind, does the necessity for a discission arise. This gain is so obvious that the only further exposition it needs is to refute what the capsule-laceration operators say in its disfavour, *viz.*, that it is obtained at too great a risk; that one is playing for high stakes, and that it violates the essential conservatism of correct surgery inasmuch as it introduces an unnecessary risk for the sake of advantages which can otherwise be more safely and equally obtained, *viz.*, by a subsequent discission. In deciding this, the following points requiring consideration naturally arise (1) Are the risks we run high, or have they been magnified by our opponents? (2) If high, are they more than compensated by the distinct advantages gained? (3) Can the capsulotomy operation, even after a discission has been performed, claim equal advantages? (4) Is a discission operation practically free from risks? (5) If not, are the advantages gained compensatory enough?

As far as extraction in the capsule is concerned these cannot be answered on the strength of a meagre number of operations. Manipulative dexterity and experience play an important role, for the more cataracts you extract, the less frequently does the vitreous escape, and the capsule burst. I shall not go so far as to assert that whether a capsule is opaque or not before operation, it is always opaque after operation; this would not be consistent with clinical facts, but we can never be sure of its transparency. Herbert says that with ordinary extraction followed if necessary by needling, quite as good results can be obtained, and with much less risks, and at the cost of merely a little more troublesome and protracted after treatment. Elliott (I.M.G., May 1906) did 75 discissions in 810 extractions with no bad results. He waits a month after extraction and atropises the eyes for another 10 days, this means a stay in hospital for over a month, an example of patience which is rare to find imitated in other parts of India. In India, where most of our patients are uneducated, 10 per cent. of extractions would more than represent the discissions performed, whereas in Europe it is more frequently resorted to, and in America, Knapp always operates on a cataract with a view to subsequent needling being necessary. The frequency of its performance also depends on the manner in which the capsulotomy has been executed and the anterior chamber cleared of lenticular debris. That this need does frequently arise is evident from the numerous ways in which we are advised to do the capsulotomy, and the discission operation itself. The object being to get rid of as much anterior capsule as is possible, but no importance is attached to the posterior part of the capsule (which is said to be nearly always transparent), as being likely to lower vision, except to ascribe to it the quasi-important function of a supporting diaphgram. Recently, extraction of the anterior capsule by means of special capsular forceps has been strongly advocated and Treacher Collins gives a series of 100 extractions so treated, in which only 4 cases required subsequent needling; this is about the best that has been obtained, but I would add, not without risk. Imitation we know is the sincerest form of flattery, and in comparing these various capsulotomy procedures, each so satisfactory to its respective advocate, with extraction in the entire capsule, we have an attempt at imitation; the attempt however is only half-hearted, because,

although they admit that the retention of the anterior capsule is a disadvantage, and do their best to extract as much of it as they can, they do not extract the posterior part of the capsule lest vitreous escapes, and the integrity of the eye be surrendered, yet they think nothing of pushing this very structure, together with adherent lens matter,into the clear vitreous when doing a discission operation. They say that when properly safe-guarded a discission is free from risk, let me agree that it is "*practically*" free. I use the word "*practically*," guardedly, for we are not working in a sterile field, and can never be sure that the eye is bacteria free until the test of an operation has been applied, and the result has pronounced the verdict. Certainties in theory are not always so in practice, or to use a sporting phrase "Many horses are beaten when they ought to have won." That this small operation is at times a dangerous one is abundantly proved. Deverux-Marshall reports 512 discissions with 1·02 per cent. suppurations, and 5·58 per cent. inflammatory changes resulting in total loss of sight. Trousseau gives 19 discissions, with panophthalmitis 1, iritis 4, cyclitis 1, and irido-choroiditis 1; De-Gama-Pinto in 198 discissions, reports 9 vitreous incarcerations and 4 suppurations. Panas says that cyclitis, vitreous opacities, glaucoma, and retinal detachment are not infrequent after discission. These are carefully compiled opinions of some of the Masters of Europe, and with this array of evidence, I ask Is a discission operation practically without risk, even using the word "practically" in its most liberal form? And willingly as I admit that by its performance vision is improved, yet are the advantages gained commensurate, or equal to those aimed at and obtained by extracting in the capsule? Is the jeopardising of an eye to infection for a second time devoid of risk? And, to quote them, is vitreous escape, or incarceration, detachment of the retina, glaucoma, destructive irido-cyclitis, practically devoid of risk? On the contrary I unhesitatingly assert that it is pregnant with danger, both immediate and remote; for can any surgeon say that when he needles an after-cataract, the instrument penetrates the capsule and "*it*" only, that he does not churn up the vitreous in a varying degree, that he does not court a mixing up of clear vitreous with lens capsule and inflammatory lenticular debris, and is such a procedure to be considered as practically devoid of risk? He will be a bold surgeon who can say this with equanimity. We might well turn the tables and ask the capsule-laceration advocates if they are not striving for an advantage at too great a risk, and playing for high stakes, and have they followed up their discissions for years afterwards, as we are asked to do with our escapes, to prove that the operation is also devoid of "*remote*" risks. I would go further and state that the risks they run are higher on account of the possible rekindling of old inflammatory mischief. It is for this reason I maintain that the necessity of a secondary discission stamps the capsule-laceration operation not only as an imperfect one, but as infinitely inferior to extraction in the capsule. The object of both these operations is to restore sight; in one, the capsule laceration, this is accomplished with extracting the lens, and is frequently followed by iritis and secondary cataract, or, in other words, to cure one disease you at times produce another which requires vigorous after-treatment of atropine and mercury, and yet another, which requires a subsequent needling, or some other surgical interference; whereas in the other operation, intra-capsular, sight is restored with one operation only. I would not be far wrong if I compared these two operations for cataract to the treatment of a cyst; one in which the sac is left behind to refill (discission), or to slowly heal by granulations (post-operative iritis), and the other in which the entire sac is removed and healing occurs by first intention (intra-capsular).

Absence of capsular impaction in the incision.—That (except in a few cases when the capsule bursts and is left behind) the absence of these tags in the incision must be considered as another of its advantages, is evident from the very operation itself. It must be equally apparent that there is a constant dread of this happening after a capsulotomy operation, as evidenced by the various ways we are advised to cleanse the edges of the incision. It is admittedly a drawback of the operation, for besides being an omnipresent drain for infection, it retards healing, and is said to be the chief cause in the development of post-operative glaucoma; any frequency of this last complication is denied by many capsule-laceration operators, although Herbert attributes his comparative freedom from it to the formation of a filtrating cicatrix under the conjunctival flap which he always cuts out. An attack of glaucoma is also likely to develop some time after extraction has been performed; it is therefore not only an immediate but a remote complication. Capsule-laceration operators refuse to connect these late developments of glaucoma with any fault of the operation. I have no statistics with me, but is not this connection just as legitimate a one as that made by them, between vitreous escape and a late detachment of the retina in the intra-capsular operation, and are they in possession of carefully compiled statistics to prove that this is not so?

Fewer instruments.—There is no doubt that for over-free instrumentation one has often to pay a penalty. Especially is this so in cataract extraction, where it is seldom if ever needed. In extracting in the capsule, besides the knife only one other instrument, the iris forceps, is introduced into the eye and as the piece of iris caught is excised, it practically amounts to one instrument. This must, although only in a minor way, reduce the chances of septic infection, and should be recknoned as an advantage. In this connection I would point out that the irrigator is not needed, as it is in a capsulotomy operation, from which it is inseparable. I have no desire to minimise the many advantages obtained by intra-ocular irrigation, it is safe enough in a fully staffed and equipped hospital, but my mofussil experience has taught me to look upon it with respect and suspicion, *vide* I. M. G., Vol. XLIII (1907), page 450. Col. Herbert, on page 241 "Cataract Extraction," very correctly sums up the infective risks attending intra-ocular irrigation, which he says are "*real*" though small, and not of the gravest,

Convalescence.—This is considerably shortened in the intra-capsular operation, the patient being able to leave hospital on the 7th or 8th day; there is no need for a prolonged detention to treat those benign, yet troublesome, grades of inflammations or needling operations so common to the capsule-laceration extraction. This gain counts for much in India.

Visual results.—To prove that not only is there a higher percentage of good vision but also more acute vision, I have given a series of results of both operations as obtained by different surgeons:

Table B refers to Smith's intra-capsular and Herbert's capsule-laceration results.

Table C refers to 100 cases of double cataracts (200 extractions) done by me in which one eye was operated on by the intra-capsular method and the other with a capsulotomy. I did not pick or choose my cases as to their suitability to one or the other operation, except that all immature cataracts were extracted in the capsule, and the capsule was lacerated when there was evidence of increased tension (this was present in 6 eyes). In this series I varied my incision to prove my belief that there is a definite connection between the position of the incision and vitreous escape. Full details will be obtained in an early publication of the B. M. Journal. These tables speak for themselves; they prove most conclusively that vision is more acute. My results are worked out on Jessop's classification: that is, a "*success*" when with glasses vision is at least 6/36; "*partial success*" when vision is less than 6/60, and at least large objects are distinguishable; "*failures*" when there is perception of light only.

TABLE B.

Operator.	Variety of operation.	Nos. operated on.	Successes.	Partial successes.	Failures.
Smith ...	Intra-capsular.	2,616	99·27	0·38	0·34
Herbert ...	Capsule laceration.	1,262	92·1	6·2	1·7

TABLE C.

Variety of operation.	Nos. operated on.	Visual results.							Below 6/60 and counting fingers.	Vision lost.
		6/6	6/8	6/12	6/18	6/24	6/36	6/60		
Intra-capsular	100	27	13	13	16	15	6	4	5	1
Capsule laceration.	100	4	3	11	20	18	19	13	10	2 (includes one panophthalmitis due to lachyrmal disease).

Disadvantages :—

Frequent loss of Vitreous.—The frequency of this complication is pointed out as the "*chief*" drawback of extracting in the capsule, and to this is attributed the immediate and remote consequences I have already enumerated. Before discussing them I shall first refer to the frequency of escapes in both operations. In intra-capsular, the percentage varies from 6 to 38 per cent., being dependent on many factors, *e.g.*, behaviour of the patient during and after extraction; size and position of the incision, being more frequent the nearer it approaches the sclera and *vice versa*; skill and experience of the operator and assistants, especially for left-eye extractions; proper selection of cases; avoidance of haste and excessive pressure; inhibition of the orbicularis and other extrinsic ocular muscles, indiscriminate use of the speculum, etc., etc. Smith had 6·8 per cent. in 2,616 extractions and has since reduced this. Birdwood 35 per cent. in 311. Maynard 38·28 per cent. in 175. Oxley 35 per cent. in 80. Knapp had 13 escapes in 104. Drake-Brockman (doing Pagenstecher's operation) 28·67 per cent. in 293. My own results work out at 10·50 per cent. in 811 without selection, less with selection, and 6 per cent. in immature cataracts. Smith tells me that some of his recent visitors have done 3 to 400 extractions with a little over 5 per cent. escapes. Against this, in the capsulotomy operation, Elliot gives 27 per cent., Maynard 4·3 per cent., Herbert 3 per cent., and my own 3·75 per cent. Glancing at these figures it is apparent that the escapes "*are*" more frequent in intra-capsular extraction. In my first 100 operations I had 22 per cent. escapes, which shows that it improves with experience. I have performed over 800 extractions in the capsule, and, excepting 9, the other escapes were very small. In this connection I would like to point out to our opponents that the percentages they give do not correctly represent all their escapes, for they do not include those discission operations in which vitreous is incarcerated or hangs out from the needle puncture; this would slightly increase their numbers, especially if discission were performed as frequently as it should be done; moreover, no mention is made of the numerous instances, after a discission, when the vitreous is displaced and occupies the anterior chamber. This condition might suitably be called an escape of vitreous into the anterior chamber, and differs from an ordinary escape only inasmuch as it is likely to raise and not lower tension, for the other evil effects are, practically speaking, common to both varieties of escapes.

I shall now take up each of the evil results attributable to an escape :—

Impairment of Vision.—As it would not be fair to take any one individual operator's results to prove that vision is *not* impaired, I have collected, as well as I can, the results of various surgeons and represented them together in Table **D**. There may be minor errors here and there, but I am dealing with these results collectively. In this table I have not included Oxley's last 40 extractions in the capsule, with 40 per cent. vitreous escapes, successes 95 per cent., failures 5 per cent. Birdwood's 311 intra-capsular cases with 47 to 35 per cent. vitreous escapes, successes 90·9 per cent., and 849 laceration extractions with 91 per cent. successes are also not included, as he does not classify his visual results. I would also point

out that Drake-Brockman performed Pagenstecher's operation.

TABLE D.

Operator.	No. of cases.	Vitreous escape %	Vitreous escapes (Approximate total.)	Successes.	Partial successes.	Failures.
		Intra-capsular.				
Smith ...	2616	6·8	176	99·27	0·38	0·34
Drake-Brockman (Pagenstecher's operation).	293	28·67	83	66·21	28·32	5·46
Maynard ...	176	38·28	51	92·5	5	2·5
Gidney ...	811	10·50	94	90·5	8·25	1·75
Totals (average).	3,896	21·31	404	87·12	10·49	2·51
		Capsule laceration.				
Herbert ...	1,262	3	38	92·1	6·2	1·7
Elliott (I. M. G., May 1906).	200	2·7	5	89	9·5	1·5
Drake-Brockman.	293	5·80	15	65·18	28·65	6·81
Gidney (last series).	1,000	3·75	40	82	15·75	2·25
Totals (average.)	2755	3·81	98	82·07	15·02	3·06

On examining the totals of these two distinct series it will be observed that in 3,896 intra-capsular operations, with an average vitreous escape of 21·31 per cent. (*i.e.*, 404 total escapes), the average visual results work out, successes 87·12 per cent., partial successes 10·49 per cent., failures 2·51 per cent.; whereas in 2,755 capsulotomy extractions, with an average vitreous escape of 3·81 per cent. (*i.e.*, 98 total escapes), you have successes 82·07 per cent., partial successes 15·02 per cent., failures 3·06 per cent. This means that although the average percentage of vitreous escapes is about 7 times higher in the intra-capsular operation, yet the successes are better by 5 per cent. and the failures show a lower figure. The same differences are observed even if I exclude Smith's intra-capsular results, which stand in a class by themselves, and Herbert's capsule laceration results, in fact, the vitreous escapes would then be 8 times higher. This surely does *not* prove that vision is impaired. Our opponents might say that these figures represent the immediate results only, and that a later examination would reveal poorer statistics, owing to the remote evil consequences. Might we not say the same of their figures, especially when we remember the dire results which have followed discission operations, and the slow inflammatory troubles which are not unknown to this operation. Let them prove this; as far as my experience goes—and I have been able to follow up some of my large and small escapes for some time—with "*very*" few exceptions, I have observed no deterioration in vision. Why should there be? When vitreous is lost, it is replaced with a clear fluid, secreted probably from the ciliary region, which not only restores tension and the support the retina is said to require, but allows rays of light to be transmitted; in other words, a functional vitreous, one which subserves optical functions, is restored. An anatomical vitreous, alike in every respect to the original, is not vitally necessary for sight, for the framework and migratory cells have played their part, and are practically the final degenerative remains of the once primary embryonal connective tissue, and possess no optical functions.

Septic infection:—When vitreous escapes, septic infection, immediate or remote, is said to be more likely to occur. If this were so, surely sufficient time has elapsed for it to be proved beyond doubt. We cannot accept this on the strength of isolated cases, small series, and such remarks as "It is only fair to attribute to this source some of the infective inflammations which follow early or late. I have thought that after escape of vitreous in our practice infective losses were more frequent." There are expressions and impressions but not the facts which we ask for. Smith in 2,616 extractions had 9 copious escapes of which three were completely lost, he makes no mention of sepsis as the cause. In 2,494 of these cases he had 9 failures, all from sepsis, but does not mention if vitreous escaped. Oxley, with 26 escapes, mentions no sepsis. Herbert (I. M. G., February 1906) mentions no sepsis in a series of 22 escapes. Maynard had 2 infections in 67 escapes, but from the details he gives of his failures, the capsule burst in most of them. In my 94 escapes I had one infection. In Table D we have 405 escapes, with an average of 2·5 per cent. failures from all causes. Elliott reports 58 escapes in 2,000 laceration extractions with 2 cases of poor vision, one occluded pupil (probably due to retained lens cortex) and one Hypopion. L. M. Mukherjee, Transactions, Indian Medical Congress, 1894, quoting from the Calcutta Oph. Hospital records, gives 28 failures in 122 escapes; 9 of these ended in atrophy of the eye and the others in septic infection. In this connection I would draw attention to the period these cases represent, *viz.*, on or before 1894, a time when conjunctival antisepsis was barely understood or appreciated. Moreover, it was at this very Congress that Bamber published 210 extractions free from sepsis; the very first series of good results published in India. I would also quote from the Madras Hospital records of 1897 when there were 75 septic infections in 1,161 ordinary extractions, to show that conjunctival asepsis was even then in its infancy. The age of these records render them valueless. Let me view it in another way. Elliott recently reports 1,000 laceration extractions, his vitreous escape is 2·7 per cent., which makes a total of 27 escapes, yet he mentions no case of infection as being due to this. Herbert gives 1,872 laceration operations, his vitreous escape is 3 per cent., that is a total of 56 escapes, he also makes no similar mention of sepsis. This works out 83 escapes with no septic infection. Now, the prognostic import-

ance of an escape is very different in the two operations; as far as sepsis is concerned, in the one, with a few exceptions, the lens in its capsule is extracted, and with an escape the worst that happens is that the edges of the incision are bathed with vitreous, a structure whose histological elements are practically negative; in the other, with almost every escape, the capsule with lens cortex is left in the eye, moreover since the toilette of the incision cannot be attended to, there is an additional path for infection afforded, owing to the impaction of capsular tags. It is also recognised that the quantity lost has very little influence. The question now arises: If an escape does expose an eye to septic infection, after which operation is this more likely to develop? In an eye from which vitreous admittedly escapes more frequently, but is rid of all cortex and capsular impaction in the incision, or one in which the capsule and lens debris are left in the eye, with tags of capsule impacted? I think there will be very little doubt that it is more likely to develop in the capsule laceration operation, and yet two of its well-known advocates have had no infection in 83 escapes. Surely this does not support them in their dread of septic infection. In this, I decline to include septic infection after a discission complicated with vitreous escape or incarceration, for, in these cases, other causes are present, especially rekindling of an old inflammatory mischief. In a copious escape, with the eye emptied out, septic infection is conceivable, but such escapes are the exceptions. In this connection I might ask: For every single case of septic infection due to vitreous escape, how many are there which can be traced to retain cortex? In my opinion this fear, though real, is very small and has been exaggerated. To be established it must be supported with a large series of cases more recent than 1894. Viewing the question with our present-day knowledge of conjunctival asepsis, I maintain that although an escape is an undesirable complication, yet, even when moderate in quantity, the eye is not more prone to septic infection. This charge might have been more justly brought some years ago when it was common to all varieties of extraction. With septic organisms present, infection will take place, mild or virulent and irrespective of vitreous escape and the so-called supporting diaphgram, but with adequate precautions as we now take, sepsis will always be the exception. The chief problem which affects all surgical results is the exclusion of sepsis, and, as far as ophthalmic operations are concerned, this largely depends on attention to details and the care used in the preparation of the operation field. Herbert struck a true note when he said "Probably Smith's relative immunity from infective losses is attributable to his preliminary douching of the conjunctival with 1 in 2.000 perchloride."

Detachment of the Retina.—That this developes after an escape of vitreous in such frequency as to constitute a drawback in intra-capsular extraction has yet to be established. If this were ophthalmologically proved it would undoubtedly be the death-blow to the operation. Its occasional development after an enormous escape, owing to a loss of support, is conceivable, but such escapes are rare and there are many large escapes showing no signs whatever of detachment. Smith says it is a rare development, so rare that he sees no function of the supporting diaphgram keeping it in its place, and his opinion is based on 17,000 extractions in the capsule. In my 94 escapes 9 were large. I have repeatedly been able to examine 19 of these cases and in none have I observed any signs of retinal detachment. Maynard and Elliott make no mention of it in their escapes. Herbert, in commenting on 22 escapes, of which 3 could see only moving objects, says that "Two cases '*almost*' certainly had retinal detachment," and again, in a footnote, *possibly* all three had; there is nothing definite about this. Even admitting the connection between vitreous escape and retinal detachment, surely we should be supplied with more definite and exact knowledge than we now possess. It "*must*" be uncommon, otherwise how can this absence of evidence on the part of our opponents be explained. This cannot be due to either lack of material or time, for if I confined myself to the totals of Herbert, Maynard, and Elliott, the three largest laceration operators in India, at say 5,000 extractions each, this would give a supply of 500 escapes, which is sufficient material; but I share with them the difficulty in following up cases for any length of time. The European surgeons are, however, pointed out as the authorities; well, why have none of them come forward? They may on this point have a very decided dread of the after-consequences of vitreous escape; so have all of us of pus from a pyo-salpinx or appendix entering the abdominal cavity; the latter is apparent and has been proved, but not so the former, which is assumptive; surely their experience and facility of following up cases should give us more definite knowledge, especially is this now needed, considering the remarkable revival of extraction in the capsule not only in India, but in Europe and America. If a retinal detachment be due to loss of support, then it should be more commonly observed after intra-capsular operation; if due to the fixation of vitreous tissue to the corneal incision, discission puncture, or tags of the posterior capsule after this has been needled it would develop more frequently after a capsule-laceration extraction followed with the discission, when the vitreous must to a varying extent be disturbed, enter the anterior chamber and adhere to the torn edges of the capsule; again if due to other causes unconnected with the operation—and this is not unlikely—it has to be proved. We are in possession of small series exhibiting retinal detachment after both operations, but for the settlement of such an important point we require more proof than a few recorded cases, and although we have no desire to minimise the consequences of very large escapes, yet until the proof is supplied we feel that we are more than justified in extracting in the capsule, in believing that this fear of retinal detachment has been enormously exaggerated, and in ascribing to it a position of importance much lower down in the list of cataract sequelæ than the evil effects of retained lens debris and capsule.

Hæmorrhage.—That this occasionally happens is evident from the isolated cases reported from time to time. The only large series I can find in the literature at my

disposal, is one given by Quackenboss of Boston, who reports three cases in 3,624 extractions: a proportion of 1 in 1,200. It is a rare complication, and considering that it occurs after both operations and irrespective of the loss of vitreous support, the cause appears to be some degenerative changes either in the Choroid or Choroidal vessels; if this was not so, it would be more frequently observed after vitreous escape. I have had experience of two such cases, both women, one after a copious vitreous escape, and the other in 1905, after a capsule laceration operation with no escape. In both patients there was evidence of renal disease, which has led me to think that marked arteriorsclerosis is at times a contra indication to cataract extraction.

Delayed Union.—This disadvantage might have been mentioned years ago when conjunctival asepsis was not so thoroughly understood and appreciated as at the present day. In any case in Intra-capsular extraction you rid the incision of the presence of capsular tags and this is a decided gain.

Prolonged lowering of Tension.—In my Intra-capsular extraction I have had little experience of this complication. I am better acquainted with it in my capsule-laceration work, when much of my time was devoted to treating not a few post-operative inflammations possessing all the symptoms of Irido-cyclitis.

Distorted Pupil.—I confess that I have seen this follow extraction in the capsule, but in my opinion it has no certain connection with an escape of vitreous, for I have observed it when there was no such loss. Its mechanical action I am not prepared to discuss till I have microscopically examined a case. It is unsightly, but I would rather have a distorted black pupil, with no capsule or exudate behind it, than one which is adherent to the capsule on its entire posterior surface, possessing a limited degree of mobility, and occupied at times, except when "*efficiently*" needled, with a structure varying in density from a thin web-like posterior capsule to a thick opaque film.

Toilette.—The difficulty, and at times the impossibility, of attending to the toilette of the incision is a weak point of both operations complicated with vitreous escape, but, as previously remarked, you have no fear of capsular impaction when extracting in the capsule.

Supporting Diaphragm of the Eye.—If the posterior part of the capsule were possessed of any function after the extraction of the lens, its utility and value of retention, intact, might be seriously considered, but as the very structure for which it was developed and was in existence, has been taken out, and as one can never be sure that this part of the capsule will be found transparent till after the lens is extracted, and when, if opaque, it will require subsequent needling, I maintain that its retention has nothing to commend itself, except, taking another view, to lower vision and to add yet another to the already numerous operative procedures necessary after cataract extraction, and which in this particular operation can be done in many ways, each supporting the other as an open confession of one of the weak spots of capsule-laceration. In this connection I might ask our opponents, what happens to this supporting diaphragm when a discission is performed, does it still possess its function? No, this new function given to the posterior capsule is of mushroom growth, one of convenience and not of utility. Exclude sepsis and eschew such sentimentality.

Incarceration and prolapse of Iris.—Smith does not mention this in his experience. Knapp reports 17 in 104 extractions, but as no iridectomy was performed, they are valueless. Maynard had 5 prolapses. Oxley and Birdwood mention that the Iris is likely to be caught at the angles of the incision, and such was my experience at first. I have practically excluded this from my last 300 extractions; I attribute it to the use of Eserine (Oxley) after every operation, and the situation of my incision, which I have called "Corneo-sclero-corneal" and which I consider to be the most suitable for Intra-capsular extraction, for, ending as it does 1 mm. below the upper periphery of the cornea, it offers a strong mechanical and anatomical bar not only to Iris prolapse but vitreous escape.

Increased Astigmatism.—For this to be adduced as a serious objection, it must be proved with carefully compiled statistics, and until this is done we can afford to ignore it. In my experience using the incision which I recommend, and not disturbing the dressings till the 4th day, unless called for, I find all my cases evenly healed and with no higher degree of post-operative astigmatism than after a capsule-laceration extraction. As other surgeons, who have recently started extracting in the capsule, are reading papers, I shall refrain from remarking on its suitability or otherwise for beginners except to say that this operation offered no terrors to me when I began.

Excessive Pressure.—If a proper selection be made the need for excessive pressure seldom arises. It appears to be more often resorted to in sunken eyes with abnormally small cornea, a condition in which extraction in the capsule is clearly contra-indicated. More pressure than usual is at times needed to extract a lens complicated with posterior synechiæ; its chief necessity, however, is too small an incision. My practice is, if I find after moderate pressure that the lens has not started to move, I at once examine the incision, and if necessary enlarge it, and try again, using steady, uniform, and slow pressure. If the lens still refuses to move which is "*very*" rarely experienced, the case is evidently not suitable for Intra-capsular extraction, and rather than wilfully court rupture of the capsule and a large escape of vitreous together with the results of prolonged instrumentation, I lacerate the capsule and extract in the ordinary manner. I have had to do this 7 times, but the need for it happened more frequently during my early cases. In these 7 cases I noticed that more cortex came out with the lens than is usually observed in such operations, possibly the prolonged pressure of the Strabismus Hook forced the soft cortex, and compressed it against the upper edge of the capsule.

I have entered into all the points brought forward by both Schools and I leave it to you to decide if what is gained on the one hand by extracting in the capsule, is lost on the other hand; whether the dangers of the operation are real and have been established, or as Mark Twain said of the announcement of his own death "grossly exaggerated."

EXTRACTION OF CATARACT IN THE CAPSULE.

By R. JAMISON, M.B., B.CH. (R.U.I.), BELFAST.

That extraction of the lens in the capsule is the ideal method of dealing with cataract has been admitted by all ophthalmic surgeons since operations for cataract were first attempted, and many have tried to raise the subject from the plane of mere academic interest and occasional involuntary accomplishment to that of practical ophthalmic surgery.

Various methods have been adopted hitherto and all have failed to satisfy the profession that they were any improvement on the ordinary operation and most of them have been given up even by their introducers.

These methods have been roughly of three classes:

(1) Direct pulling out of the lens by means of hook, forceps, or wire loop.

(2) Dislocation of the lens before extraction; this has been done after the completion of the corneal incision by pressing on one border so as to turn the lens completely over and make it come out posterior surface foremost, by dislocating it into the anterior chamber by means of a probe passed behind it through the sclerotic; and by detaching the lens from the zonule of Zinn by means of a curved sharp instrument called a zonulotome.

(3) Delivery of the lens by means of a spoon passed behind it into the vitreous as was practised to some extent by Pagenstecher. From *a priori* reasons the first two methods are destined to failure. The lens capsule is an exceedingly delicate membrane—how delicate only those who have tried intra-capsular extraction, especially of a swollen lens, can appreciate—and direct force of such strength as to accomplish the desired effect is almost certain to either rupture it or injure it so much that it tears when the lens is being expressed. The result attained is exactly what the operator wished to avoid; he has only succeeded in performing the ordinary operation by a more complicated method and has exposed the eye to the risks of sepsis and traumatism from so much intra-ocular manipulation.

The third method deserves more notice, though it has been given up by Pagenstecher himself, owing to the frequency of rupture of the capsule and prolapse of vitreous.

A slight modification of this method, which I shall describe later, has to be adopted in certain cases at Major Smith's clinic and has given excellent results. In the light of the experience gained in this procedure I believe that the failure of Pagenstecher's method was due to the facts that he had no special means of dealing with intumescent and ripe swollen lenses, which are exceedingly liable to burst owing to the stretched and tense condition of their capsules: that his method of using the spoon inflicted more damage on the contents of the eye, than does the method used at Jullundur; and that much of his escape of vitreous was due to the pressure of the lids not being properly kept off the globe.

This list of operations is sufficient to show the amount of importance surgeons have attached to the intra-capsular removal of the lens, and the amount of dissatisfaction they have felt with the results of the capsulotomy operation.

A solution of the difficulty of extraction in the capsule has been found in the Indian method of dislocation and expulsion of the lens by means of pressure on the cornea, so that no direct pressure is put on the lens which is forced out of the eye by the counter pressure exerted by the contents of the globe. In Major Smith's hands this operation has proved a success beyond the dreams of ophthalmic surgery, and has made cataract extraction almost the simple, safe and effective operation that the public unfortunately believe it to be. Hitherto this operation has not proved so successful with other surgeons as it has with Major Smith and the main object of the present paper is to show that others can get almost as good results.

Working under the personal supervision of Major Smith, as an absolute beginner at cataract extraction by any method I have had the following experience:—

Number of cases.	Escape of vitreous.	Iritis.	Poor vision (below $\frac{6}{60}$).	Capsule left behind.	Suppuration.	Expulsive hæmorrhage.
260	14 5 1%	4 1·5%	11 4·2%	8 3·%	2	1

And I do not stand alone in obtaining such results by this method. I have seen Captain McKechnie do about 300 out of his total of 500 of these operations, and know that his results, especially as regards freedom from after complications such as iritis and suppuration, are better than these.

These figures require a few words of explanation and criticism. Of course as a beginner under the care of a teacher my cases were at first, to some extent, chosen for me and not until I had done about a hundred had I acquired the necessary amount of experience and dexterity to do cases simply as they turned up. At first too I failed to dislocate some of the lenses without using an unjustifiable amount of force and had to give up; had I persevered with such cases disaster would probably have been the result, so that when we take into account such cases and the fact that the first hundred were more or less selected, it is evident that these figures are much above those that a beginner doing all sorts of cases, and specially one merely from a book

description of it, might reasonably expect to have. It might be argued that for the same reasons they are not suitable statistics and are too flattering to the intra-capsular operation, but closer analysis shows that it is not so: half the vitreous escapes, one suppuration and the one bad case of iritis occurred in the first hundred, so that if we take the last 160 as the proper cases for statistical purposes, seeing that they were done without the slightest attempt at selection and without any help whatsoever, the figures would be more flattering still.

The after history of the fourteen cases of vitreous escape was:

Good vision	... 9.	Suppuration...	...1	Hæmorrhage	...1
Iritis ...	... 1.	Poor vision due to capsule left behind	...1		

Four of the escapes occurred in the attempt to remove with iris forceps the remains of capsules which had ruptured. This procedure often results in the escape of a bead of vitreous, and the one case of severe iritis followed it.

The expulsive hæmorrhage was peculiar and I do not believe it was the result of escape at all; the escape was slight, not more than a drop, and the hæmorrhage did not occur until at least five hours later. As a matter of fact escape of vitreous in many of these cases of hæmorrhage is the result of hæmorrhage not *vice versa.* The sequence is: the patient complains of sharp pain in the eye, vitreous begins to flow copiously a few seconds later and is soon followed by blood. I have seen it occur once on the table after the operation had been completed and no escape had occurred. Indeed in Major Smith's experience it is quite independent of escape of vitreous; and in my solitary case of it, it is likely that if due to the escape (small though the latter was) it would have occurred at the time and not some hours later when the defect had been largely made good by secretion of aqueous; so that we reduce the list of possible evil consequences of escape of vitreous in the series to one, the case of suppuration, and that one is not a remarkable result when we take into account the filthy condition of the conjunctivæ of many of the eyes operated on.

Iritis.

The freedom from iritis is one of the great features of this operation and one that has been observed by every surgeon who has performed it. In the present series of cases there were only four examples of this complication; two of these were very mild and cleared up in a few days under mercury internally and leeches to the temple; the third case was more serious and was longer in subsiding but left good vision eventually. The last one was severe and the result was only perception of moving bodies; it was the case referred to in which there was considerable trouble in extracting the capsule of a lens which burst when being extracted.

Into the much discussed question of the cause of iritis following cataract extraction I do not intend to enter fully here. Suffice it to say that neither of the theories of traumatism or sepsis will hold water. There is considerably more bruising of the iris between the lips and especially the angles of the wound and the emerging complete lens, than there is when only the nucleus is expressed; if due to sepsis why is it that while panophthalmitis has been so reduced by careful asepsis and antisepsis as actually to lead one prominent Indian operator recently to suggest that in the near future the surgeon may be held legally responsible for this rare complication, iritis has not been correspondingly reduced, in fact not reduced at all?

Bad Vision, i.e., *below* $\frac{6}{60}$

Eleven cases of this occurred. One was due to dense capsule having been left behind; as the other eye had been done at the same time and the result was excellent the patient refused to have anything more done. One was due to the above mentioned case of severe iritis following a case very similar to the preceding. One was due to glaucoma; the patient was suffering from glaucoma in both eyes and, as he also had dense cataracts in both eyes, extraction was done in the more promising one but with little hope of securing good vision. One was due to haziness of the cornea which I believe would eventually clear up; in this case too both eyes had been operated on and, as he had good vision in the other, the patient refused to stay in hospital to have the clearing of the cornea hastened by a short course of mercurial treatment. Two were due to panophthalmitis. One to expulsive hæmorrhage. Three to retinal atrophy (as shown by a history of night blindness); one man had this condition in both eyes, the other case had only one eye done, the other not having even the faintest perception of light and so not being a suitable case for operation. One we could find no cause for. So that of these poor results the first two were due to a faulty operation, but they would clear up considerably on the needling of the after cataract which was the cause of the poor vision; the case of corneal haze would clear up too. Four of the cases, the glaucoma and the three cases of retinal atrophy were not in any way connected with the operation, and so cannot be regarded as results of it, so that, even considering the three improvable cases as poor results, the total number in any way connected with the operation was seven, *i.e.*, 2·7 per cent. Capsule was either completely or partially left behind in eight cases. Bursting of the capsule is a serious complication. If left behind it exposes the eye to the risk of iritis and to the necessity of a needling operation, an operation that in the opinion of many is more dangerous than the original one, while if extracted in the way to be described later there is liability to escape of vitreous and to iritis and panophthalmitis from too much intraocular manipulation introducing sepsis.

Suppuration occurred in two eyes. One case followed escape of vitreous, the other followed a normal operation. Considering the condition of many of the eyes operated on this is a marvellously small proportion. Amongst the Punjab peasants at least 15 per cent. of the eyes are in such a state of chronic conjunctivitis, usually from trachoma, that rigorous treatment for weeks or months would not put them into a condition in which a European surgeon would touch them. Such treatment is impossible here, a patient will not stay in hospital longer than two days before operation, at the end of which time he leaves to fall into the hands of the coucher, whose operation is ruinous to the eyes, either immediately from sepsis, or remotely from atrophy of the retina, which follows the presence in the vitreous of even such an apparently innocuous foreign body as the lens.

The immunity from sepsis is due to two causes; first, the small number of instruments introduced into the eye, and second, the use of a douche of 1 in 2,000 mercuric chloride to wash out the conjunctival sac immediately before operation. This douche is used from a reservoir about four feet above the patient's head so that a powerful stream is obtained: the germs are thus washed away and the lotion remaining in the sac forms, with the tears, a weak solution which inhibits the growth of any germs that are left. The use of this solution is never followed by any ill effects; there is no doubt that is the cause of a good deal of conjunctival injection seen when the eye is opened on the sixth day, but that always clears up in a few days, and it may also help to cause some of the more marked cases of striped keratitis, also a temporary condition; in only one case have I seen a marked opacity such as is said to follow the use of such a solution and it had all the appearances of an exaggerated type of striped keratitis and in all probability would have cleared up in a few days if the patient had remained in hospital.

The one case of expulsive hæmorrhage has already been discussed. Prolapse of iris undoubtedly occurs somewhat more frequently here than it does in the case of cataract extraction by the old method, but the cause is the want of control these patients have over themselves and that the hospital has over them. During the busy seasons the hospital staff is quite too small to cope with the large number of cases so the patient has perforce to be left very much in charge of his sick attendant, who is usually a fellow villager or relative of his; the consequence of this is that he may be found out of bed on the second or even the first day and some of them actually remove the bandages every few hours to see how the eyesight is progressing.

Comparing these results with those obtained by the capsulotomy method, we find that the percentage of escape of vitreous (5·1) is almost as low as that obtained by even experienced operators by the old method namely 3·5. Vitreous escape however has not the evil effects that follow such an accident in the capsulotomy operation; when it occurs in the latter case the eye is immediately shut up with the capsule and most of the lens matter left behind to cause iritis and iride-cyclitis with probably late detachment of the retina from shrinkage of the inflammatory exudate. By the intra-capsular method all such foreign matter is removed from contact with the iris and vitreous, inflammation never occurs, and the result is quite as good as if no such accident had taken place.

The question of iritis hardly admits of comparison at all; it is practically absent in intra-capsular operations, being found only when some such accident as rupture of the lens capsule has occurred; owing to the absence of such accidents in Major Smith's own cases iritis is the rarest of complications.

Poor vision as we have seen resulted in only 2·7 per cent. of my cases (excluding the four fundus conditions and including the three cases that could be improved); it has never been reduced below 7 per cent. by the old operation with needling. By the new method even the good cases show a much higher average of good vision, $\frac{6}{6}$ and $\frac{6}{5}$ are quite common and the vision of all cases goes on improving for a few months until the wound has cicatrised to its maximum, while in the old operation vision gets gradually worse owing to the increasing opacity of the capsule. One of the greatest advantages of the former operation is the great reduction of cases with visual results between about $\frac{6}{24}$ or $\frac{6}{36}$, and moving bodies, when they do occur, are due to fundus conditions, not to after effects of the operation in the form of after-cataract or iritis and its consequences. Such visual result is almost as great a disappointment to the patient as complete failure; he is unable to read ordinary print or writing or do any work which requires a similar acuteness of vision.

The incidence of detachment of the retina, detachment of the choroid and the amount of astigmatism is independent of the nature of the operation and so is not open to comparison. The incidence of sepsis depends on the thoroughness of the preliminary douching, but, as there are fewer instruments introduced into the eye, risk is less in the intra-capsular operation.

Briefly comparing the relative merits of the two operations, we have the frequent occurrence of iritis in the one, its almost complete absence in the other; the universal after-cataract in the one with its necessary treatment which is subject to as much risk as the original extraction, and the absence of after-cataract in the other; the easy and very effective solution of the question of the immature lens afforded by the intra-capsular operation compared with the years of worry, anxiety and financial loss which ensue before the patient can get relief by the old

operation; the frequency of tags of capsule in the wound in the old operation forming a drain which, if not covered by a conjunctival flap, is certain to become a septic drain (and thus explain the greater frequency of sepsis in the old operation compared with the new), and the consequent necessity for making a conjunctival flap to seal up these tags rapidly, a flap which Captain McKechnie will prove to an absolute demonstration is certain to be followed by more astigmatism than the Jullundur incision which is an approach to a radial one; intra-capsular extraction admits of any incision and owing to the absence of material in the wound which would form a channel for septic organisms, admits of the incision which will be followed by least astigmatism namely a radial one; the difference in the after-treatment of the two cases in the old operation the eye has to be inspected daily and to receive drops of atropine either on account of the presence of iritis or to anticipate its onset and often, to combat iritis, the patient has to undergo saturation with mercury in the intra-capsular operation, the eyes, as a rule, are not touched until from the sixth to the tenth day when the patient may be given a green shade and allowed to go home. Any surgeon will at once recognize the advantage of the operation which has no after-treatment over the one which is followed by much after-treatment, in short the intra-capsular operation stands at least as far ahead of the old operation as litholapaxy stands ahead of lithotrity. In litholapaxy the stone is crushed up and evacuated at one sitting, in lithotrity the stone was crushed up at one or more sittings and the fragments left to be expelled by the forces of nature which meant great inconvenience to the patient and was always followed by a considerable amount of inflammation of the bladder. The Indian surgeons Keegan and Freyer disposed of lithotrity for ever. Indian surgeons will dispose of the incomplete operation for cataract in the same way.

With such advantages to commend it, and such figures as those of the operators who learn this operation under Major Smith to prove that others can do it almost as well as he can, the operation ought to be a universal one and why it is not so depends on several factors, of which I believe the following are the most important.

The operation is not an easy one but the difficulty lies not so much in the operation itself as in the acquiring of proficiency in the various devices which have to be adopted to suit different conditions, here comes in the immense advantage of learning the operation under the instruction of one who is thoroughly acquainted with all its details, who knows from long experience how certain classes of lenses are likely to behave and how accordingly they must be treated, who can give directions as to the amount and the direction of pressure and how and when they must be altered, and who knows why certain complications are likely to ensue and how they must be avoided.

Even then it cannot be learned by simply watching such a man doing it and listening to his teaching; it must be practised under his supervision and thus learnt quickly and thoroughly: otherwise proficiency will be gained as the result of bitter experience and probably an evil reputation as a cataract operator, after a large percentage of escape of vitreous, many burst capsules, many failures to accomplish the operation without using unjustifiable force, a few couched lenses, and much reaction in the eye as a result of too much interference with it.

The consequence is that the beginner working by himself concludes that the operation is not practicable and gives it up in disgust or despair, or he selects those cases that his limited experience has taught him are most likely to do best and deprives many a patient of the benefits of the operation, which is feasible enough in all cataracts in adults, if the operator only knew how to do it. The next factor is the assistant; in no other operation in surgery does he play such an important part: it is no exaggeration to say that an untrained or unskilful one will spoil almost as many eyes as an unskilled operator. His duties are just the same as in the old operation until after the iridectomy has been done, the speculum is then taken out and the assistant has to take all pressure off the globe and take care at the same time that he keeps his hands and arms out of the way of the surgeon. He stands at the surgeon's left side and pulls the lower lid downwards by means of the face of his left thumb placed on the cheek just below the lid, a little pad of wool beneath his thumb enables him to maintain a firm hold if the cheek is moist; at the same time he lifts the upper lid straight forwards, or forwards and slightly downwards, never upwards as thus the peripheral fibres of the orbicularis would get a chance of exerting pressure on the globe; he does this by means of a hook like a stout strabismus one held between the thumb and the first two fingers of the right hand like a pen in writing, it being held at such a length that the tips of the ring and little fingers fully extended can push the peripheral fibres of the orbicularis upwards on the forehead and keep them there by pressing firmly on the upper margin of the orbit. This, in addition to preventing the orbicularis from getting at the globe, gives a good view of the upper fornix and thus exposes the field of operation, for during the operation the patient is allowed to keep his eye in whatever position he likes and in the great majority of cases he rolls it strongly upwards, in this way there is no trouble with the patients who are unable to look in any required direction or with those who cannot maintain the eye in such a direction: there is also no risk from sudden movements as the eye is invariably maintained in the

position first chosen, and the patient's nerve is not shaken by shouting at him or continually giving him directions. The assistant must remember to keep his right wrist strongly fixed to allow the surgeon to get his left arm between the assistant's right arm and the patient's head. This seems a lot of stress to lay on the duty of one who in most operations has a very subordinate part to play, but any person who has experienced the poorer exposure of the field of operation, the more frequent escape of vitreous and the hampering of his left arm by an unskilled or clumsy assistant will soon have any lingering scepticism about the importance of his subordinate banished.

The third point which makes for success is the knowledge of the behaviour of lenses according to the stage of their maturity. Contrary to common opinion the order of ease of intra-capsular extraction is: (1) immature, (2) intumescent and ripe swollen, (3) hyper-mature shrunken.

The immature lens comes out with the greatest ease; pressure is applied with the end of a spatula held vertically in the left hand like a pen over the lower third of the cornea close to its left margin, and, with the point of a blunt hook similar to the one used for raising the upper lid, over the lower third of the cornea between the end of the spatula and the right margin. The direction of the pressure is straight backward towards the optic nerve. The spatula does not move but the point of the hook may be drawn two or three times slowly across the cornea until the lens appears in the wound and is about half delivered, then the pressure of the hook is slackened and its direction gradually changed from backward to upward, so as to fold the corneal flap under the lens until the latter topples over on the cornea. During this stage the hook exerts gradually less and less backward pressure until at the end the pressure is directed entirely upwards, while the spatula keeps up just enough backward pressure to prevent the lens slipping back into the eye. By this means the lips of the wound are kept close to the lens and there is little room for vitreous to escape even if there were enough pressure to force it out. When the lens topples over the spatula is taken off the globe and the lens is caught in the hollow of the hook which is pressed well under it so that it is lifted away, not pushed or pulled away, by the point of the hook for fear of rupture of the capsule which may still have a slight attachment to the zonule. The same means is adopted to take away the lens when as occasionally happens it stays between the lips of the wound and does not topple over; only in this case enough pressure is kept up with the point of the spatula to prevent it retreating into the eye until it has been removed from the lips of the wound. These manœuvres, though difficult to describe in an intelligible manner, are always easy in practise and it is a rare thing indeed for an immature lens to give any trouble. Fortunately for the patient most Indian operators have recognised this fact and when a selection is made it is always the immature lens they choose.

Next in order come the intumescent, mature swollen and the Morgagnian which has not undergone much shrinkage. The condition common to these is the swelling of the lens and the stretched and weakened capsule which is extremely likely to burst when the lens is about half out. If such lenses be extracted by the above method, they are dislocated first close to the wound and when the capsule ruptures it is pulled back into the eye by the intact lower part of the zonule and has either to be extracted with forceps or left behind, and we have already considered the risk that the eye runs from either of these procedures.

The following method enables us to overcome the difficulty with these lenses. Apply the spatula and hook as before and first proceed to define the ciliary ridge which can be felt as a hard resisting body when we try to move the hook from the cornea to the sclerotic; then, keeping up just enough pressure to prevent the point of the hook slipping over this ridge, pull as if trying to make the patient look down. The effect of this proceeding is to make the zonule rupture below and the lens tumble upwards so that the lower border comes first through the wound. This pull is kept up until the lower border of the lens begins to appear at the wound, the pressure is then changed gradually from downwards through backward to upward, the point of the hook following the emerging lens and folding the cornea beneath it as before. Rupture is still likely to occur owing to the great delicacy of the capsule, but not so much so as when the upper border comes first, because the attached portion of the zonule being now close to the wound is more directly acted on by the escaping lens and less force is required. Even so, many of them still rupture when the lens is half or more out, but as the capsule is now attached above it does not slip back into the eye but remains between the lips of the wound and can be easily lifted away with a pair of dissecting forceps. The method is specially applicable to these swollen lenses as the large amount of fluid matter they contain makes them easily mouldable; it is much more difficult to acquire proficiency in this than in the preceding method and the beginner is likely to fail in making a good many of his swollen lenses turn a somersault upward, but once he has acquired the knack he has completely surmounted the difficulty of delivering these lenses in their capsules, a difficulty that has been the great obstacle to all the methods of intra-capsular extraction, and that no one has hitherto succeeded in getting over.

If by some mischance a ruptured capsule retreats into the eye it is dealt with in the following manner, a pair of iris forceps is passed closed into

the anterior chamber as close as possible to the back of the cornea (as the capsule often lies close up to the latter) until the points appear about the centre of the pupil, then the points are allowed to separate as widely as possible consistent with the size of the pupil and are driven straight back into the vitreous, closed and pulled out, usually they bring the capsule with them either wholly or partially, if the former well and good, if the latter it is more efficient than any needling later would be. If this fail to catch the capsule, let it alone and needle it afterwards, any farther manipulation is not advisable as vitreous is rather likely to escape during these attempts, and we have also to always remember the risk of infection that too much intra-ocular interference carries with it.

Last comes the hypermature shrunken lens.

The operator should recognise that this is a hypermature lens from the fact that the lens and iris are farther back than normal in the eye: he as a consequence assumes that this is a small shrunken lens. The intumescent cataract is both weak in the capsule and easily extracted probably from its being swollen, the hypermature is both strong in the capsule and strong in its attachment, anyhow it is the most difficult of all lenses to dislocate. In dealing with this one the object should be to make it turn a somersault in the same way as the intumescent variety: this is not always easily done, if we fail to do it the lens dislocates opposite the middle of the wound and we see that it is dislocated by the point of transparent vitreous in the wound. The moment we see this we cease all efforts to make the lens turn a somersault, but keep up as much pressure with the point of the hook as will keep it in position; we then drop the end of the spatula into the vitreous behind it and continue to drive it out by pressure on the cornea with the blunt hook on the spatula as an inclined plane, using the spatula merely to support the lens and to prevent the pressure which is being applied to the cornea from acting on the vitreous. If the patient is at all well behaved there should be no escape of vitreous in these cases. Once a hypermature lens dislocates at the wound if we go on simply pressing we will only succeed in driving out the vitreous, so firmly anchored are these lenses. The object of making this lens turn a somersault is to obviate the introduction of a spatula into the vitreous to remove it.

Another class of lens to which attention should be directed, is what Major Smith calls the "soapy lens." It differs, on the one hand, from the bluish white mother-of-pearl appearance of the intumescent lens and, on the other, from the opaque milky white of the mature or hypermature swollen lens. It is very well described by saying that it has the appearance of ordinary coarse white soap. Such a lens has a very tough zonule and is very difficult to dislocate: fortunately, however, it is very rare.

There is one important point in the behaviour of the patient bearing on the success of the operation, namely, that a patient who looks down during the operation is much more likely to have escape of vitreous than one who looks up. I think this is due to the eye being in a strained position (the eye when at rest turns upwards) and so there is likely to be greater intra-ocular pressure, but perhaps the manipulations are not so skilfully performed in this very unusual position.

A very well marked feature of the operation and one rather difficult to account for is the much greater liability to escape of vitreous in prominent eyes when all pressure has been taken off the globe than in those that lie deeply in the orbit. Such I believe are the main considerations bearing on the successful performance of the operation, which has no terrors for any one who has had enough experience, has a good assistant and knows how to vary his methods according to the varying conditions he finds.

The opponents have obtained their arguments from two sources; from those who without any preliminary teaching and experience have tried the operation and got such results as up to forty per cent. of escape of vitreous, large numbers of burst capsules, delayed healing, etc.; such statistics are not a fair criterion of the value of the operation, they have been obtained by novices at a difficult and extremely tricky operation and for future comparison the figures of those who have learnt the operation from Major Smith should be cited instead.

The second source of supply has been from the records of more timid operators who have tried intra-capsular extraction of shrunken lenses because the thickened capsule and thinned zonule were supposed to make these cases particularly suitable; the same objection applies to these figures as to those of the first set and in addition the experiments have been tried on the most unsuitable condition of lens for this operation.

These arguments have been mainly along two lines, firstly the accidents that are liable to happen at the time of operation and secondly the remote result of such accidents, the answer to the first is that such accidents as escape of vitreous and rupture of the capsule are extremely likely to occur with the novice, but with increased experience in the proper performance of the operation they become less and less frequent and there is no reason why any Indian operator should not obtain almost as good results as those of Major Smith himself.

The answer to the second will be supplied by Captain Lister's paper on the after-results of cases of escape of vitreous, which should banish once and for all the extreme terror that ophthalmic surgeons have hitherto held for what they consider the worst complication next to expulsive hæmorrhage that can occur in the course of a cataract operation.

THE COMPLETE REMOVAL OF CATARACT.

(SMITH'S OPERATION.)

BY CAPT. J. C. S. OXLEY, I.M.S.,

Civil Surgeon, Seoni, C. P.

The advantages of removing the cataractous lens complete in its capsule, when successfully performed, are, I think, generally acknowledged.

As objection has been taken in some quarters to calling this "Smith's operation," I have alluded to it in this paper as the "complete" operation.

I venture to think that this term gives a more clear idea of its difference from the old operation, which is admittedly incomplete, than does the term "expression" which has sometimes been used. As a matter of fact all cataracts are expressed except those removed by a spoon or forceps. It is sometimes overlooked that the mere removal of the capsule, important as it is for vision, is only one of the advantages of the operation.

Elimination of simple iritis and prevention of incarceration of tags of capsule in the wound are of almost equal importance.

Knapp's[1] "peripheral division" operation was devised expressly to secure these two advantages. The opponents of the "complete operation" oppose it on the ground that the risks incurred are too great. Objection seems to be chiefly taken to one particular feature of the operation, *viz.*, increased liability to vitreous loss. Some authors, while forced to admit that in Major Smith's hands the operation is an improvement, have endeavoured to show that in the hands of the average operator the operation is not justifiable. Col. Maynard [2] says "no operation should be judged by its best results but by its average, and that too in the hands of the average ophthalmic surgeon. So judged extraction will hold its own."

Again Col. Herbert [3] remarks "The question of the applicability of this method hangs mainly upon the risk of vitreous accidents, infective inflammation, detachment of retina, atrophy of globe, &c."

It should be remembered that escape of vitreous has a very different significance in the old incomplete operation to that which it has in the "complete operation."

In operating by the old method, escape of vitreous necessarily meant leaving behind in the eye a mixture of vitreous, soft matter and capsule. This very frequently does lead to a bad result. As pointed out by Hall[4] "vitreous retards absorption." When operating by the complete method however such a state of things can only be brought about by a double accident, *i.e.*, rupture of both hyaloid and lens capsule.

These cases which alone are comparable to vitreous escape by the old method (as only in them are the conditions similar) amount in the present series to 21 or 5·5 per cent. They should be much less numerous.

Most published statistics of this operation in the hands of operators other than Major Smith show a large proportion of vitreous losses, Major Birdwood[5] 37 to 47 per cent., Col. Maynard 38·28. Myself in the present series 27·3. Speaking for myself, I must attribute this to defective technique. I have not been able to see Major Smith operate since 1904. I understand that recently several operators have, under his instruction, performed a large number of operations with results, as regards vitreous escape, scarcely inferior to his own. The very fact however that the vitreous escapes in my series are somewhat numerous lends additional interest to my results.

I wish to remark that in nearly every instance the amount lost was extremely small. It is these small losses that are, I maintain, without any injurious effect on the eye. There is no danger of late detachment of retina. This is supported by the experience of Fuch's Clinic. As Meller[6] says "Detachment of retina occurs only after great loss of vitreous except in an eye especially predisposed." With this view I entirely agree.

In point of fact I have not seen a single case of late detachment of retina, but I saw one case of large detachment which occurred before the patient left hospital. (*Vide* II, No. 52.) In this case the cause was quite obscure as there was no escape of vitreous or rupture of capsule at the operation (which went indeed particularly smoothly), and the other eye of the same patient, operated on at the same time, had vision $\frac{6}{10}$. I am inclined to think that some accident must have occurred in the ward as the eye subsequently showed the characteristic pupil of large vitreous loss and the iris became drawn up.

I have to present to you the immediate results of 378 consecutive extractions in the capsule and also a series of 100 of these cases which I have been able to follow up for periods varying from 3 months to over 3 years. These 100 cases were not in any way selected but simply represent all I was able to get hold of.

Comparison between the 2 series as regards vitreous escape, rupture of capsule, iritis and suppuration, will show that the cases followed up do not include a disproportionate number of operations free from any complication. In fact as the smaller series includes *all*

[1] Knapp.—Archives of Ophthalmology and Otology, Vol. VI, page 545.

[2] Maynard.—Manual of Ophthalmic Operations, 1908, p. 108.

[3] Herbert.—Cataract Extraction, 1908, p. 257.

[4] A Few Words about Senile Cataract, 1899, p. 24.

[5] Birdwood.—Ind. Med. Gazette, XLI, p. 201.

[6] Meller.—Ophthalmic Surgery, 1908. Translation by Pyle, page 154.

the suppurations and one iridocyclitis, in all of which vision was *nil*, it is the other way about.

	No. of cases.	Vitreous escape.		Capsule ruptured.		Iritis.		Suppuration.	
		No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
Primary ...	378	103	27·3	39	10·3	7	1·9	3	0 8
Late cases ...	100	...	29	...	17	1	...	3	...

One objection urged against the operation is that infection is invited by vitreous escape. If this were the case I ought to have had an undue number of suppurations as my vitreous losses amounted to 27·3 per cent.

These 378 cases include 3 suppurations and 6 closed pupils from iritis. The eyes were prepared in nearly every case only by mechanical flushing out of the conjuctiva by boric lotion after the instillation of any good drugs. This series of 378 may be compared with Col. Herbert's[7] series of 349 which included 3 suppurations and 7 closed pupils which occurred when he was using a dilute mercurial solution.

The advantage being slightly in favour of my series with less antiseptic precautions, but considerably more vitreous losses, appears to indicate that vitreous loss does not specially predispose to septic infection.

As a matter of fact incarceration of capsule in the wound, which is entirely eliminated by the complete operation, is a much more dangerous complication. As regards the frequency of this accident by the old method, Swanzy[8] found that in about 25 per cent. of cases he was able to remove tags of capsule by the method he describes. It was also presumably occasionally overlooked.

Parsons[9] states that incarceration of capsule, on account of its toughness, is much more dangerous than that of lens, fibres or vitreous; as besides keeping open the wound "it is always surrounded by marked lymphocytic infiltration leading specially to cyclitis." It occurs "in the absence of bacterial infection" but also "a more acute inflammation is not infrequently set up by bacterial infection along the spongy track, ... and the eye is lost by panophthalmitis."

I have tabulated the late cases according to the vision, as follows :—I also append the full details of these cases as a supplement to this paper.

100 cases.	I V = $\frac{6}{6}$	$\frac{6}{9}$	52
	II V = $\frac{6}{10}$	$\frac{6}{15}$	26
	III V = $\frac{6}{20}$	$\frac{6}{30}$	9
	IV V = Below	$\frac{6}{30}$	13

All the above were tested only with spherical lenses. In cases in which the capsule has not been left I find that improvement occurs up to about $2\frac{1}{2}$ months and that by that time vision, in an uncomplicated case, has reached its maximum $\frac{6}{6}$, $\frac{6}{9}$ with ordinary spherical glasses. When the capsule has to be absorbed it naturally takes longer. As I invariably make a purely corneal section, as described by Smith, the visual results here recorded go some way to dispose of the statement made by Czermak[10], Meller[11] and others that this kind of incision produces excessive astigmatism.

In only four instances have I found vision deteriorate after leaving hospital. This result was due in 2 cases to drawing up of the pupil (Nos. 34 and 23).

One of these was improved by an iridotomy and in the other case I did not advise operation as the vision in the fellow eye was $\frac{6}{12}$. In one case (No. 83) vision, which was $\frac{6}{6}$ 2 months after operation, afterwards fell to $\frac{6}{36}$. This was due to dust-like vitreous opacities and had nothing to do with the operation. There was no vitreous escape at the operation. The fourth case was due to corneal ulceration. The cases of vision less than $\frac{6}{30}$ amount to 13 and were due to the following causes.

Vision Nil six cases as follows :—

Suppuration and iridocyclitis, 4 cases (Nos. 2 56, 80, 88).

Detached retina, 1 case (No. 52).

Pupil drawn up, 1 case (No. 34).

Indifferent vision 7 cases :—

Pupil drawn up, 1 case, vision $\frac{3}{60}$ (No. 23).

Corneal ulceration after leaving hospital, 1 case, V = hand movements.

Corneal opacity antecedent to operation 1 case, V = $\frac{6}{40}$ (No. 68).

Myopia with fundus changes 1 case. The patient will not take higher than 0·75 D.S. V. = $\frac{6}{40}$ (No. 50).

Syphilitic choroiditis (Nos. 47, 48) two eyes of the same patient. It was recognised before operation, from the slight pupil reaction, that some disease existed ; but this operation enables one to undertake cases hopeless by the old method.

Thick capsule 1 case (No. 85).

It is a mistake to suppose, when the capsule gives way (unless simultaneously accompanied by rupture of the hyaloid), that the result will be worse, as affirmed by Col. Maynard[12], than by deliberately opening the capsule.

On the contrary I find that in these cases the Capsule often becomes entirely dislocated from some portion of the pupillary area giving the same result as would have been obtained by successful needling.

I think then that so far as the limited number of cases here dealt with goes I may claim to have established the following :—

(1) The operation is a safe one for the average operator.

(2) It eliminates the common complication of simple iritis due to cortical remains.

[7] Op. Cit., page 270.
[8] Swanzy.—Handbook of Diseases of the Eye, 6th Ed., p. 373.
[9] Parsons.—The Pathology of the Eye, Vol. 1, p. 161.

[10] Czermak.—Die Augen operationen, S. 1047.
[11] Meller.—Op. Cit., p. 141.
[12] Maynard—Op. cit., p. 114.

(3) It eliminates that insidious and dangerous complication, incarceration of capsule.

(4) A corneal incision without conjunctival flap does not produce excessive astigmatism nor undue liability to infection.

(5) Late detachment of the retina is not to be feared.

(6) The final visual results are superior to those obtained by the old operation.

APPENDIX.

Details of visual results in 100 cases.

Serial Number.	NAME.	Date of Operation.	Vision on Discharge.	Vision on.		Vision on.		Capsule rupture=C. Vitreous escape=V. No complication=N.	REMARKS.
1	Jangi	23-6-08	6-20	13-11-08	6-10	18-1-09	6-8	C	
2	Do.	Do.	*nil*	Suppurated.				C.& V.	
3	M. Munia	19-10-07	? ?	11-11-08	6-8	18-1-09	6-8	V.	
4	Do.	13-9-05	6-30	Do.	6-8	Do.	6-8	*Nil*	
5	Jhoulal	25-7-08	3-60	Do.	6-40	Do.	6-30	C.	
6	Do.	13-7-08	6-15	Do.	6-6	Do.	6-6	N.	
7	Bihari	16-5-08	3-60	11-6-08	6-30	Do.	6-30	C. & V.	
8	Do.	18-12-07	3-20	9-11-08	6-8	Do.	6-8	N.	
9	Balkishan	13-2-06	6-10	6-3-06	6-10	19-1-09	6-8	N.	
10	Do.	Do.	6-10	....		Do.	6-6	N.	
11	Debi	15-7-08	6-60	13-11-08	6-50	Do.	6-20	N.	Choroidal atrophy with pigment.
12	Bhadu	14-8-07	6-15	....		Do.	6-6	V.	
13	Sardari	24-4-05	good	24-4-06	6-6			V.	
14	Ramdas	31-7-05	6-12	15-10-07	6-8			V.	
15	Do.	4-8-05	good	Do.	6-10			?.	
16	M. Munia	29-9-05	good	11-11-08	6-8			N.	
17	Antee	16-9-05	good	5-10-06	6-6			C.	
18	Do.	17-9-05	good	Do.	6-6			N.	
19	Ramprasad	Do.	good	Do.	6-10			N.	
20	M. Gondia	12-12-05	?	Do.	6-8	3-3-07	6-8	?.	
21	Manak	22-4-06	6-12	2-7-06	6-10			N.	
22	M. Balama	21-4-06	3-16	7-6-06	6-30			V.	Other eye blind from couching. Large pterygium.
23	Amrit	7-7-05	good	4-5-06	1-60	8-5-06	3-60	V.	Pupil drawn up, iridotomy. Diabetes.
24	M. Bhagirathi	11-8-06	?	12-9-06	6-12	20-10-06	6-6	V.	
25	Biharilal	5-10-06	good	3-3-07	6-8			N.	
26	Lalji	29-9-06	good	16-10-08	6-10			V.	
27	Do.	Do.	slight	Do.	6-15			V.	
28	M. Gondia	31-12-06	good	3-3-07	6-6			N.	
29	Harchand	6-3-07	good	29-5-08	6-6	23-1-09	6-6	C.	
30	Do.	Do.	good	Do.	6-8	23-1-09	6-8	N.	
31	Bishan	22-8-07	good	29-9-08	6-15			N.	
32	Do.	Do.	good	Do.	6-8			N.	
33	Hiralal	21-8-07	good	Do.	6-12			V.	Considerable V. escape.
34	Do.	Do.	slight	Do.	*nil*			V.	Pupil drawn up.
35	Dost Mahomed ...	19-11-07	6-60	17-2-08	6-8			N.	
36	Do.	Do.	6-60	Do.	6-20			N.	
37	Manglu	15-12-07	3-60	24-1-08	6-8			V.	
38	Do.	Do.	6-60	Do.	6-8			V.	
39	M. Bibi	17-12-07	6-30	12-1-09	6-8			N.	
40	Do.	Do.	6-30	Do.	6-6			C.	
41	Beni	29-12-07	good	29-1-09	6-12			N.	
42	Har sigh	Do.	good	Do.	6-8			N.	
43	Do.	Do.	good	Do.	6-8			N.	
44	M. Margi	4-1-08	good	29-9-08	6-15			N.	No patience to test further this querulous creature.
45	Do.	Do.	good	Do.	6-15			N.	
46	Nanha	Do.	good	16-10-08	6-15			C.	
47	Chaitu	9-9-08	1-60	21-1-09	2-60			N.	Choroidal atrophy syphilitic
48	Do.	Do	1-60	Do.	1-60			N.	Do. syphilitic.
49	Haiderkhan	16-1-08	6-20	Do.	6-15			C.	Myopia with fundus changes.
50	Do.	Do.	fingers	Do.	6-40	Capsule removed 2nd operation.		C.	Takes 0·75 D.S.

APPENDIX—(*continued.*)

Serial Number.	NAME.	Date of Operation.	Vision on Discharge.	Vision on.		Vision on.		Capsule rupture=C. Vitreous escape=V. No complication=N.	REMARKS.
51	Jiria	15- 5-08	6-10	11-11-08	6-10	12-1-09	6-10	N.	
52	Do.	Do.	*nil*	Detached retina.				N.	
53	Goharkhan	5- 6-08	6-8	6- 1-08	6- 6			N.	
54	Do.	Do.	6-40	Do.	6- 8			N.	
55	Jangi	23- 6-08	6-20	13-11-08	6-10	18-1-09	6-8	C.	
56	Do.	Do.	*nil*	Suppurated.				C. & V.	
57	Sheolal	21- 6-08	good	30-11-08	6- 8	30-1-09	6-8	V.	
58	Do.	Do.	good	Do.		Do.	6-8	N.	
59	Rukhma	26- 8-08	good	1-10-08	6-12			V.	
60	Do.	Do.	good	Do.	6-15			V.	
61	Ammu	Do.	good	Do.	6-20			N.	
62	Do.	Do.	good	Do.	6-10			N.	
63	M. Batobai	28-11-08	good	3-13 08	6- 8	12-1-09	6-6	N.	
64	M. Zainabi	Do.	3-60	12- 1-09	6-15			V.	
65	M. Kesar	21-12-08	3-60	15- 1-09	6-30	4-2-08	6- 8	N.	
66	Do.	Do.	3-60	Do.	6-60	Do.	6-6	V.	
67	Sher Mahomed	3- 7-08	?	10- 8-08	6-12	23-1-08	6-6	N.	
68	Do.	Do.	?	Do.	6-40	Do.	6-40	C.	Old leucoma of cornea.
69	Azamkhan	18-11-07	6-60	Do.		Do.	6-30	V.	
70	Bhopali	22- 5-07	6-6	3- 2-09	6- 6			V.	
71	Do.	18- 5-08	6-15	Do.	6- 8			N.	
72	M. Munkharia	29- 7-08	6-60	18- 1-09	6- 8			N.	
73	M. Jugo	27- 1-08	6-16	1- 2-09	6- 6			V.	
74	M. Anupa	23- 3-08	6-8	23- 1-09	6- 6			N.	
75	Do.	Do.	6-20	Do.	6- 8			N.	
76	M. Nanhia	Do.	3-60	Do.	6- 8			N.	
77	Do.	Do.	3-60	Do.	6-10			C.	
78	M. Subeti	Do.	6-12	Do.	6- 8			N.	
79	Do.	Do.	6-10	Do.	6- 8			N.	
80	M. Jira	19- 9-08	*nil*	Suppurated.				N.	
81	Do.	Do.	6-20	27- 1-09	6-15			N.	
82	Rambux	21- 6-06	good	24- 8-06	6- 8	31-1-09	6-8	C.	
83	Mullu	24- 8-06	good	3-10-06	6- 8	Do.	6-30	N.	Vitreous dust.
84	Sardari	5- 2-08	good	Do.	6-15			V.	
85	Do.	Do.	good	Do.	6-40			C.	Thick capsule unabsorbed.
86	M. Radha	21- 6-08	good	Do.	6-10			N.	
87	Do.	Do.	good	Do.	6-10			N.	
88	Chamri	8-06	......	Iridocyclitis.		*Nil.*		N.	
89	Do.	Do.	......	24- 8-06	6- 8	31-1-09	6-8	N.	
90	M. Subhana	2-10-06	good	31- 1-09	6-10			N.	
91	Do.	Do.	good	Do.	6-12			N.	
92	M. Tulsia	1-10-08	good	31- 1-09	6- 8			N.	
93	Tulsia	Do.	good	Do.	6- 8			V.	
94	Raganath	20-12-07	good	Do.	6-20			V.	Pat. squeezed out lens and considerable vitreous.
95	M. Jugu	8-06	good	Do.	6-10			N.	
96	Do.	Do.	good	Do.	6-20			N.	
97	Tulsi Ram	15- 2-06	Fair	27- 8-06	6- 8			N.	
98	Do.	Do.	Fair	Do.	6- 8			V.	
99	Phagwa	17- 4-06	$\frac{6}{40}$	5- 2 09		Hand movement.		C. & V.	Central ulcer of cornea, after leaving hospital.
100	Do.	Do.	$\frac{6}{8}$	Do.	6- 6			N.	

THE AFTER-TREATMENT OF CATARACT OPERATIONS.

By Senior Assistant Surgeon KIDAR NATH BHANDARI,

Hall Gate, Amritsar.

My experience of this subject extends to about 9,000 cases of cataract operations whose after-treatment I have done myself or has been done under my observation. Out of these 9,000 cases Daviel's operation or the Capsulotomy operation was performed in about 2,000. Of these 2,000 about 1,000 were operated on by a most experienced surgeon in the Mayo Hospital of Lahore the remaining 1,000 cases were operated on by myself and other surgeons at different places. The remaining 7,000 cases were extracted in the Capsule by Major Henry Smith, I.M.S., at Jullundur Civil Hospital.

Treatment—The importance of securing as much and as perfect rest as possible for an eye after cataract extraction cannot be overestimated. In no surgical procedure is the beneficial influence of rest in the after-treatment more marked than in operations on the eye. To secure this rest it is necessary to dress up and exclude both eyes from light, even though only one eye be operated on. If the eye not operated on be exposed to light it is consciously or unconsciously used and its movements cause corresponding movements in the other eye. Even light which falls on the retina of the eye not operated on causes a sense of inconvenience in the eye operated on though the latter be excluded from light.

The most convenient dressing when leaving the operating table is to smear the margins of the eyelids with some sterile ointment such as grains VIII to the ounce of yellow oxide of mercury in thin vaseline. This prevents the eyelashes from being gummed together and renders it easy to remove the dressing when such is afterwards being done. If the dressing is done so that the eyelashes become gummed together, considerable petty inconvenience to the patient results in the following days until the eye is redressed. On the top of this application a piece of mercury gauze should be placed over both eyes and a thin pad of coloured antiseptic or sterile wool placed over the gauze and a figure of 8 bandage applied over all. We want to exclude light and coloured wool does this better than white wool. The wool should be sufficient in thickness to exclude light and dust and always within the limit which will admit of the bandage putting pressure on the eye. The figure of 8 bandage is the best of all bandages. It is simple, it is easily applied, it remains in position and being drawn over the natural prominences of the region it is least liable to put pressure on the eye. If all cataract cases were dressed thus, we would not hear of the reaction against any dressing seriously discussed. This reaction is a reaction against placing a thick pad over the eye through which the bandage presses on the eye ball.

The patient should be kept in a room with a dull light as it is very difficult to exclude strong tropical light from an eye by dressings. He should rest on his back for the first 24 hours. For the following three days he may rest on his back or on either side according to what he finds most convenient. After 4 days he may be allowed to sit up in bed. He should have no food or drink for the first 6 or 8 hours after operation so as to avoid the slightest provocation to vomit. For a few hours after operation patients do not seem to digest food or fluid put into their stomachs, and when such food is there for a short time nature seems disposed to get rid of it by vomiting. Such vomiting may cause detachment of the Choroid which is accompanied by bleeding, generally free and often severe. Indian patients seem to do best on a diet of rice and milk for the first three days, after which they may be allowed their usual food. The food should never be rich and should not contain hot spices. The tobacco smoker should have his smoke in moderation and the opium eater should be allowed his ordinary ration of opium. The bowels should be kept regular and easy throughout, and if they have not been regular, an Enema of 4 drachms of Glycerine, the morning after operation or subsequently will give him an easy free motion. Our practice at Jullundur in recent years has been to give every full blooded or corpulent person, as well as those suffering from Gout or Diabetes, 5 grains of Blue pill at bed time on the day of operation to be followed by a Siedlitz powder early the following morning. This clears out his bowels without straining and without purging and as a laxative I regard it as the best. His bowels should never be allowed to get into such a condition as causes him to strain at stool. Any irregularity of the bowels in the way of constipation is at once reflected on the eye and when such does occur there is nothing more marked than the rapidity with which it disappears after the operation of Blue pill 5 grs. and a Siedlitz powder.

When the patient is removed from the operating table the Hospital nurse should be in touch with him for at least two hours so as to be on the look-out for the first symptoms of the form of surgical shock which occasionally follows operations on the eyeball. This shock is generally over in two hours after operations. It is peculiar in its form to operations on the eye. The patient complains of thirst, with a swimming sensation in the head often followed, either with or without a drink, by vomiting, which is the cause of most cases of detachment of the Choroid. The vomiting is more certain to occur if the patient drinks than if he does not, hence the patient should not get a drink to relieve his thirst. He should, on the first appearance of thirst, get a hypodermic injection of $\frac{1}{3}$ grain of morphia which relieves all his symptoms of shock including thirst like magic.

Detachment of the Choroid is known at once by the hæmorrhage which causes it, accompanies it, and follows it, and which is often very considerable and quickly makes its way through the dressing. On taking off the dressing, blood clot and vitreous are seen in the wound as well as free bleeding. In severe cases the effusion behind the Choroid may have emptied the globe of vitreous. Once detachment of Choroid occurs the eye is invariably lost and as the hæmorrhage is often severe the best practice is to excise the eye-ball as soon as possible. I wish to emphasize the fact that detachment of the Choroid is generally preventable if a hypodermic injection of morphia be administered on the first appearance of shock, and if no food or drink be given for the first six or eight hours after operation ; of course an occasional case of detachment of the Choroid will occur without warning ; in these latter cases the patient suddenly complains of a sharp pain in the eye and bleeding immediately commences. In some such cases no evident disease of the arteries or of the eye previously existed though in most there has previously been Glaucoma, Gout, Diabetes or Nephritis ; hence it is necessary that these patients should have their bowels well cleared out before operation.

As regards the treatment on the days following that of operation, it differs immensely according to the operation performed, *i.e.*, the Capsulotomy or Intra-Capsular operation. In the case of the Capsulotomy operation the eye should be inspected daily so as to detect the onset of iritis as soon as possible. Iritis is not always painful. This daily inspection is necessitated on account of the frequency with which iritis follows the Capsulotomy operation, and, after this operation, drops of atropine should be instilled at the time of inspection so as to keep the pupil dilated in anticipation of iritis. I say to keep the pupil dilated, as I assume the patient was well under the influence of atropine at the time of operation as he always should be, not to facilitate extraction of lens but to maintain dilatation of the pupil after operation in anticipation of the onset of iritis. No other drops are necessary. In Intra-Capsular extraction iritis is so very rare that it is not necessary to inspect the eye till the sixth or even till the tenth day when the wound will have healed. It is thus evident that the Intra-Capsular method admits of the principle of rest whereas the Capsulotomy method does not, and as a result the wounds in the former heal up much more rapidly than in the latter. No atropine is necessary in the after treatment of the Intra-Capsular cases on account of the absence of iritis. In the Intra-Capsular cases in which iritis does occur the capsule has burst at the time of operation and has had to be left behind and this fact is of course always noted by the operator who writes up the bed head tickets at the time of operation. Major Smith marks cases on the bed head ticket in which iritis is to be expected at the time of operation and it is exceedingly seldom that a case of iritis which he has not anticipated at the time of operation occurs. In the intra-capsular operation it is not necessary to inspect the eye unless pain indicates some complication. A trifling stinging pain follows all operations on the eye and may be neglected. More severe pain calls for inspection. It may be caused by iritis, irido-cyclits or by infection of the eye. Prolapse of the iris seldom causes more than inconvenience. The pain may have no apparent cause more than mere congestion, a mere angry look. In this latter case a few leeches, we seldom use less than 4 at Jullundur, to the temple and 5 grains of Blue Pill followed by a Siedlitz powder relieve the patient of his pain and the eye of its angry look at once. This effect of leeches in relieving this congestion and pain is both marked and rapid. Atropine should not be used except for the mechanical object of dilating the pupil. It is not curative of iritis or of any other condition and should be used only to secure dilatation of the pupil and thus prevent it from becoming fixed down to the after-cataract (lens capsule that has been left behind and becomes subsequently opaque) in an undesirable position. Its routine use with any other object is to be deprecated, it intensifies the congestion of the conjunctiva if any be present and if none be present it produces congestion. Atropine undoubtedly fires up trachoma if such be present, as it so very often is in Northern India. The operation which does not require the use of atropine (intra-capsular extraction) has, in this respect, a great advantage over the operation which does require its use.

Inspection of the eye.—The bandage having been removed the dressing should be softened with some warm sterile or antiseptic solution and removed. The surgeon should then draw back the brow with the thumb of his left hand and draw down the lower lid with the index finger of the same hand slightly so as to just expose its margins and then they should be cleaned with some sterile or antiseptic solution. The Jullundur practice is to do this with sublimate wool and warm 1 in 2,000 corrosive sublimate solution in distilled water. When thus cleaned in dull light the brow is drawn further back and the lower lid further down by the finger and thumb as described. In intra-capsular extraction when the eye is thus exposed, if all is well, the eye is closed and dressed up again ; if opened for the first time on the sixth day the eye is bandaged up for two days more ; if opened for the first time later than the sixth day and if all is right we use a green shade. We never wash out a conjunctival sac or use any drops at Jullundur unless there is some definite object for doing so, and such is very rare in intra-capsular extraction. In extraction by capsulotomy we expose the eye in the same way and do not wash out the conjunctival sac unless there is a definite object for doing so, but we always instil drops of atropine solution either to keep the pupil dilated in case of iritis or in anticipation thereof. It will be seen that by exposing the eye as stated above and by avoiding washing out of the sac and by avoiding any drops in the conjunctiva our grand object is to obviate the patient putting any pressure on the eyeball by wincing at the exposure of the eye to light which he always does if we are not careful. Again by the avoidance of drops or washing out of the conjunctival sac we eliminate a certain cause of wincing. Any wincing

interferes with the rest which the surgical wound should have and thus delays healing.

Iritis.—In iritis there is generally some pain though it may exist without pain. In mild cases the iris loses its lustre and in severe cases lymph may be seen on the iris and the conjunctiva be congested. To treat iritis 4 leeches should be applied to the temple without delay, atropine instilled twice daily, and every effort made to get the patient under the influence of mercury up to the point of salivation within 24 hours. To do this our Jullundur practice is to give the patient a grain of blue pill every two hours, and, if his bowels become loose, to add a little opium to it because if the bowels are loose mercury does not act with the same rapidity. Somehow or other the leeches seem to render the effect of atropine and mercury much more rapid than would be the case without them. Perhaps a hypodermic injection of Pilocarpine would do the same thing. The mercury should be kept up to the point of salivation until the condition has completely resolved. If adhesions have taken place and do not give way when the patient is 24 hours under the influence of mercury up to the point of salivation, the atropine may be stopped as in that case it is doing more harm than good ; but it is not so with mercury.

Irido-cyclitis.—I have never seen a case of cyclitis after cataract extraction without iritis. The symptoms of irido-cyclitis are more intense than those of iritis. In addition to the symptoms of iritis, the area over the ciliary region becomes swollen, the conjunctiva chemotic and the pain is more marked, so also is the lymph appearance on the iris. Often there are small lymph deposits on the back of the cornea, and sometimes there is a deposit of lymph in the inferior angle between the cornea and the iris like a hypopyon. The treatment of this condition is the same as that of iritis. The results are not always so satisfactory in irido-cyclitis as in iritis. Both these conditions are dependent on the irritation set up by lens debris and capsule left behind as evidenced by the fact that they do not occur after intra-capsular extraction, and hence it is very important that as little lens debris as possible should be left behind at the time of operation.

Occluded Pupil.—This condition is the result of iritis or irido-cyclitis produced by thickening up of the capsule with a deposit of lymph and binding down of the iris to it. In this case a few weeks after operation when the causative inflammation has subsided, the after-cataract so formed should be extracted. To do this an iridectomy sized wound should be made in the sclero-cornea and an iridectomy done. If an iridectomy was done at the time of operation, the wound should be made so that a little more iris may be excised in order to open up the posterior chamber. Through this opening a steel probe curved and mounted on a handle should be passed into the posterior chamber and the iris forcibly detached from the after-cataract little by little until the detachment is complete. Then an open iris forceps should be passed and driven through the after-cataract and closed and the whole after-cataract drawn out. The patient at the time should be under the influence of mercury and should have had atropine instilled 3 or 4 times daily for at least two days beforehand, so as to anticipate iritis which is very likely to follow such rough handling of the iris as is necessary in this operation. I have seen Major Smith do this in a number of cases which were regarded by other men as hopeless with splendid results.

Suppuration.—Once the least trace of suppuration appears in the wound the case is generally hopeless. If seen in the early stage, a point of nitrate of silver, if drawn along the margins of the wound, may stop it though like all other devices it seems almost always futile. Once suppuration seems certain to continue the sooner the eye-ball is excised the better.

Prolapse of Iris.—It is better policy not to open up the wound and try to replace the iris because this procedure ends in failure and naturally is very liable to expose the eye to infection. These cases should be cocainized by 10 per cent. solution, as 5 per cent. is not sufficient, the hook retractor for the lids used, the eye-ball fixed with a forceps so used as to cause such pressure as will balloon up the iris and the prolapsed iris should be snipped off with a sharp scissors as closely as possible, the lids being let go at once. Of course I assume that the conjunctival sac will have been well flushed out with some such agent as 1—2,000 sublimate solution after the cocainization. The eye should then be bandaged up for a few days. Cases thus treated seem always to do well.

Late pain.—Pain occasionally sets in after the eighth day without plus tension. In these cases the eye looks angry without any more evidence of disease. To treat this, the patient should have a few leeches applied to the temple and a blue pill laxative, which generally relieves the condition. If the pain persists after this treatment, it generally submits to 5 grains of Phenacetin or 5 grains of Phenalgin two or three times daily. The beneficial effect of these two drugs in this is very prompt and well marked, so much so as to lead one to think that this late pain is of a neuralgic nature. These cases thus treated always do well.

Post Operative Glaucoma.—This condition we occasionally see. It is generally seen in Gouty or Diabetic patients (the Diabetes of advanced life). It usually sets in when the wound has healed up soundly between the tenth and twentieth day after the operation. It has much of the symptoms of what I have described under *Late Pain* except that, in addition, there is plus tension. It seems to matter not whether there was an iridectomy performed at the time of operation or not. To treat these cases efficiently, the bowels should be cleared out with a mercurial laxative (5 grains blue pill), and a few leeches should be applied to the temple. The eye should be cocainized, the conjunctival sac washed out, and the eye-ball tapped every second day for two or three times by puncturing it in the sclero-corneal margin with a Graefe's Knife and bandaged up. If a trace of vitreous escapes from the puncture, it does not seem to matter. Thus treated, these cases do well. It is important that patients in which this complication is likely to arise should not be lost sight

of for up to three weeks as the complication generally sets in within that pariod. It is also very important that they should not be overfed and that their bowels should be kept strictly regular during the after-treatment.

Detachment of Retina.—This, in my experience, is an exceedingly rare complication of Cataract Extraction. It does not necessarily occur at the time of operation, when it does occur. In fact, I have never seen a case occur at the time of operation. If it does occur, it occurs in the first week after operation. My experience of it is so small (two cases) that my generalizations may be worth little, but both these cases occurred between the third and the sixth day. In both these cases the operation was perfect, the eye was all right, and vision splendid when opened on the third day. To treat this, keep the patient at rest on his back, and get him rapidly under the influence of mercury. These two cases left the Hospital at the end of three weeks with good vision and, to all appearance, perfectly cured. Both came back about three months later without vision and with soft eye-balls. The detachments had reoccurred, as all detachments have a tendency to do.

The treatment of After-Cataract does not come within the scope of this paper. There is room enough to have a whole discussion on the treatment of After-Cataract.

EXTRACTION OF CATARACT IN THE CAPSULE.

By Hospital Assistant MATHRA DAS, MOGHA.

I commenced operating on cataract in 1903 when I did 3 cataracts. In 1904 I did 41. In 1905, 155. In 1906, 317. In 1907, 501. In 1908, 804. Up till November 1905 I extracted by the Capsulotomy method, but, having read a paper on extraction in the Capsule by Major Henry Smith, I.M.S., of Jullundur, I was not satisfied with the Capsulotomy method on account of the frequency of iritis which amounted to 15 per cent.; the greater frequency, as compared with Major Smith's figures, of pan-ophthalmitis which in my cases amounted to 7 per cent.; and also to the comparatively high number of failures to obtain vision from all causes which amounted to about 14 per cent. It matters nothing in practice from what cause the patient remains blind after operation. He hesitates to come to us if we cannot show a smaller percentage of failures to obtain vision than 14 per cent. Then, in the successful cases, the after cataract, which is invariable, or almost so, leaves him poor vision for fine work and he hesitates to allow us to needle it; with few exceptions he prefers to remain with what vision he has than to submit to another operation; in short, he thinks if we have to do a second operation that the first one was bungled and he sees no reason why the second may not make him worse instead of better. This may be stupid of him, but it is he, and we must if we are to be successful treat the patient as well as the disease; we must take his prejudices into consideration. In this mental attitude I paid a visit to Major Smith at Jullundur who very kindly showed me every thing he had ophthalmic. He took great pains in showing me every detail of extraction in the capsule, what to do and what not to do and the reasons for everything.

On my return from Jullundur in November 1905, I proceeded to extract in the capsule as I have done since, excluding no case from that operation except in people under 25 years of age.

Since that date I have extracted 1,653 in the capsule. In my early experience of this operation I had more escape of vitreous than at present, partly due to the fact that I was not so skilful as I am now and partly to the fact that my assistant, who is such an important factor in this operation, was untrained: nevertheless the cases in which vitreous escaped did well; they had good vision and it remained good. I have followed up many of them and I am of opinion that no bad results either immediate or remote follow a small or moderate amount of escape of vitreous. My percentage of failures to obtain vision from all causes in extraction in the capsule would amount to about 5, and the remaining have all splendid vision: in short, after this operation the vision is either good or there is no vision at all. When we compare the difference between my 86 per cent. of cases with any vision in the old operation and my 95 per cent. with good vision in the new operation we see the reason why my hospital attendance at once increased. When I commenced Major Smith's operation the simplicity of the after-treatment, the practical absence of iritis and irido-cyclitis, the greatly reduced number of cases which suffered from sepsis, the incomparably better vision and the absence of after-cataract in the new operation, convinced me that there is no comparison between the two operations. I cannot understand how any one who knows how to do the new operation does not adopt it.

I paid a further visit to Jullundur in October last when Major Smith again showed me everything he could and in particular how to train my assistant to take charge of the eyelids; from this visit I benefited immensely as regards reduction in the number of my cases of escape of vitreous. My assistant before that visit was not competent, but with a little training as shown me by Major Smith he is now very good but not yet up to the Jullundur assistant. It takes a good deal of practice for an assistant to become *au fait* in this operation and on him depends an immense deal; almost as much as on the operator himself.

To illustrate this paper I take my last 162 cases, *i.e.*, the cases I did since my return from Jullundur. In these

162 cases I lost two from detachment of the choroid with free bleeding which occurred a few hours after operation associated with vomiting, and in one the lens slipped back and I could not get it out; I used the spoon to lift it out but could not get hold of it, the wound healed up but there was no vision probably from detachment of the retina from undue meddling with the spoon. Of these 162 cases there was slight escape of vitreous in 14, of which twelve did splendidly; the above case had no vision and another case of vitreous escape had poor vision from haziness of the cornea due to keratitis following the operation. Thus 158 out of the 162 had splendid vision and 4 were failures, making a percentage of first class vision in about 97·50 per cent. How does this compare with the old operation with its average of 86 per cent. of favourable results in my hands. In these 162 cases I had no suppuration and no case of iritis.

I hold that the operation has all the advantages over the old operation which Major Smith claims for it, and that it is destined to be the operation of the future. At the same time there is no denying the fact that it is an incomparably more difficult operation to perform and that for a beginner it is a great advantage to have a few weeks training in the art under a man who can do it properly; such will save him an immense deal of worry and dissatisfaction with himself before he becomes competent.

I owe Major Smith my sincere thanks for all his kindness and for the interest he has taken in me in teaching me how to do this operation and other things opthalmic.

EXTRACTION OF CATARACT IN THE CAPSULE.

By Capt. A. E. J. LISTER, M.B., B.S. (Lond.), F.R.C.S. (Eng.), I.M.S.

So much has been written on this subject that I fear it is difficult to add to it much of interest. However, as few writers with any considerable experience of the operation except Major H. Smith, I. M. S., of Jullundur, have recorded their actual experience, I think it is of value for other operators to place their experience on record.

My experience is based on 576 cases operated on by me, chiefly at the Civil Hospital, Jullundur, where I had the privilege of working for a year under Major Smith. Eighty-one of these cases were done at the Cantonment General Hospital, Meerut.

General Results.

Suppuration occurred in two cases, leading to total loss of the eye. One of these cases occurred in a case in which I had to introduce a spoon to extract the lens owing to vitreous appearing at the upper edge of the wound whilst attempting to extract the lens. Suppuration at the site of the wound occurred in two cases, due, I think, to infection at the first dressing, as it was left to a compounder. One of these cleared up and caused no after effects at all. The other did not clear up readily, but curiously enough caused scarcely any pain, and the patient left hospital on the 11th day to proceed home, thinking he was all right. I am unable to say whether it resulted in permanent damage to the eye. This gives a percentage of ·34 per cent. of eyes definitely lost by suppuration.

I attribute this low percentage to the use of the 1-2,000 Perchloride of Mercury douche. There is no doubt that this lotion is a strong one to use for douching the eye, as I can vouch for from personal experience of it. I had my own eye douched with it, as I happened to get some pus into it. It caused me such pain that I could not open my eye for a time, and it remained painful for four hours afterwards. Of course it must be borne in mind that the patients are all under the influence of a 4 per cent. Cocaine solution, and do not, as a matter of fact, complain of more than a little pain, but that it is a potent factor in preventing suppuration, I think, is undoubted, as very few indeed of these cases were given any preliminary treatment for the conjunctiva. I would not have operated on some of them had I not learned from observation at Jullundur that it was safe to do so if one used the douche.

Slight Keratitis occurred in two cases, which yielded readily to treatment by a saline purge, and Pilula Hydrargyri internally.

No cases of intraocular hæmorrhage occurred in my cases. No case of iritis was seen at all.

Lachrymation.—Troublesome lachrymation occurred in several cases, but usually yielded readily to treatment by instillation of weak zinc sulphate and boric acid drops. In one case, which was not relieved at all by this treatment and which persisted for a fortnight, relief was obtained by ordering the patient to douche the eye freely with cold water twice a day.

Marked injection of the conjunctiva, with lachrymation, occurred in a certain number of cases. I attribute it chiefly to an excess of the 1-2,000 perchloride lotion left in the conjunctival sac. It yielded readily to local treatment. If any marked pain was present, leeches were always applied and invariably gave relief.

One complication of great interest occurred and I have not heard of a similar one. A man aged 73, an intelligent carpenter, was operated on by me for an ordinary mature senile cataract. His pupillary reaction was normal and projection of light perfect. The cataract was extracted in the capsule quite easily and without any complication whatever. When the eye was opened for dressing on the fourth day, the man said he could not see fingers held in front of the eye.

The cornea was clear and the eye looked perfectly normal. The wound healed normally and the progress of the case was in every way normal, but he was never able to distinguish more than the movements of the hand in front of the eye and left the hospital after 17 days in

this condition. Before leaving hospital the fundus was examined but appeared normal. I was quite unable to understand why he could not see, and particularly asked him to come back again later to report progress. About three and a half weeks later he came to my house looking extremely pleased and walked into the room obviously seeing, as his other eye had been lost. He stated that a week before his sight began to come back and in three days was completely restored. That is to say, after a period of three weeks, during which he could only see hand movements, his sight was completely restored. I had no time to estimate his refraction carefully, but his vision was excellent, and I have no doubt will be $\frac{6}{6}$ when his cornea settles down. The fundus was quite normal. It is not possible to say what was the exact cause of this condition. In the absence of a better explanation, it seems possible that the removal of the lens entire—for it was a large one—may have had some effect upon the circulation of the retina, causing a temporary interference with its functions.

The man's mental condition was quite normal, and there is no doubt as to the genuineness of the history, as he was a very intelligent carpenter, who could give an excellent account of his past services.

Escape of the Vitreous.—In my series of cases, escape of the vitreous occurred 29 times. In 22 cases it occurred during extraction of the lens in ordinary cataracts. In two cases it occurred during extraction of the lens, which had been previously dislocated by the "Rawal" or native lens coucher. Including all cases this gives a percentage of 5·03. Taking cataracts whose lenses were not previously dislocated, this gives a percentage of 4·7 approximately. The only serious complications, due to loss of the vitreous in my series, was drawing up of the iris, leading to occlusion of the pupil in one case. The eye has recovered and I propose making an artificial pupil for the patient, who is still under treatment. In most of the other cases the escape of the vitreous caused no trouble at all, but in a few cases the patient suffered from lachrymation due chiefly to the edge of the iris being caught in the wound. In two cases the edges of the iris had to be snipped off.

In one case that of a very old woman, considerable flattening of the cornea resulted, and I was in despair of it getting right. In six weeks' time, however, it became all right and she was anxious to have the other eye operated on. I am in favour of using a pad sufficiently large to exert mild pressure on the eye in cases in which escape of vitreous has occurred. In one case where this was not done, I noticed when the eye was opened on the 3rd day that the cornea at the lower edge of the wound was bent away from the upper edge, and the wound gaping. This was due to a very nervous patient "squeezing" at the time of operation and after. The wound healed quite well but the iris was drawn up occluding the pupil as described before. It is interesting that, although the wound was open wide on the 3rd day, no suppuration occurred and it healed soundly when a firm pad was applied.

The percentage of escape of vitreous in the operation undoubtedly decreases with the experience of the operator and, a point upon which I wish to lay stress, the experience of his assistant.

The first point is well illustrated by my own experience. In my first series of 63 cases at Jullundur in the spring of 1907, escape of the vitreous occurred in six cases, whereas, at Jullundur in 1908, I did 64 non-selected cases in two days with only one slight escape of vitreous in one case. In this case, moreover, the patient squeezed out the lens with a little vitreous on completion of the incision. The second point is illustrated by my Meerut experience in 1908. In a series of 81 cases I had escape of vitreous in seven. I had to start operating with assistants who had no previous experience of eye operations at all and very little of surgery. I should mention also that I was handicapped by having to operate out of doors for the first 40 cases owing to want of proper light. I am quite sure that had I had a good assistant at least half of the escape of vitreous would not have occurred. I think therefore it is impossible to lay too much stress on the importance of fully training your assistant. Every operator should if possible first act as an assistant himself, to become fully familiar with all the details. When seeing a really good assistant at work, one hardly realises what an important part he plays in the operation. It is only when one has to train one, for one's self, particularly if he be not too intelligent, that one realises the importance of his part and how much damage he can do. He should be taught that, not only should he keep the orbicularis muscle well under control, but that, when placing his thumb in position for this purpose, he should draw up the loose skin of the upper lid so as to keep the eye-lids well open. If he does not do this, the operator will not have such a good view of the field of operation,—a very important desideratum. He should be taught that he must always watch the patient's expression and the moment the patient shows any sign of straining, he should take hold of the speculum lightly and be prepared to raise it, so as to prevent the patient putting pressure on the eyeball by closing of the lids, and causing escape of vitreous. A good assistant will anticipate this and avert it.

Results as regards vision.—It is quite impossible to give a statement of the exact vision obtained by every patient operated on in Indian hospitals in the Provinces. At Jullundur, owing to deficient accommodation, the patients are allowed ordinarily to leave the hospital on the sixth day.

The eye is still weak and cannot tolerate light well enough to allow the vision to be tested at a distance. In Meerut my patients are discharged on the tenth day, but that also is too early to allow their vision to be tested other than roughly. I show the patients groups of small dots varying in size from one readily seen to one as big as the ordinary full stop in print. They are asked to count these with a + 10 D. lens. If they can count down to the last size but one, I am sure from experience their vision will be about $\frac{6}{9}$ when the cornea has settled down. This may not appear very scientific,

but it is all one can do, and it is for all practical purposes sufficient. I have had the opportunity of seeing and testing many cases of my own and of Major Smith's who came back for various reasons, and from an experience which is based on certainly not less than 250 of these cases I should say that the average vision obtained after this operation, provided the eye was healthy before operation, is $\frac{6}{6}$.

Astigmatism.—I have worked out the refraction of a number of cases and find the resulting astigmatism is usually from + 0·75D. to + 1·0D. To European ideas this statement of results will appear unsatisfactory, as it has not the usual table giving the vision obtained by each case. To those, however, who know the East, and that the native of India is as well able to appreciate the value of an operation as the people of other countries, seeing that he judges by the result only, which after all is the essential point to people of any nationality, the fact that in six months, and that broken up into two periods through enforced absence, I was able to get 81 people to come forward for operation, will appeal as an argument of the first importance. It should be mentioned that this was in a small cantonment hospital, where no eye work at all had been done in the preceding year, and that all around are found, in every station, operators for cataract by the ordinary method of wide experience. Had my results been worse than those of others near me, no one who has any knowledge of India will deny that my cases would have fallen off as the results became known. I will now make a few remarks on certain points of importance in connection with the operation.

Technique.—My technique was exactly that of Major Smith, to whose kind tuition I owe almost all that I know of this operation; it has been fully described already and will be more fully described later in the press, so I shall not describe it here, but make a few observations on matters which my experience suggests may be of interest. I think that the most important thing in the operation is for the operator to have an exact knowledge of the particular way in which to extract each class of cataract. It is extremely difficult to give a description of the different classes of cataracts classified from the point of view of the operator. It is quite easy to point them out clinically, and I cannot too strongly emphasise the importance of the operator being able to tell, at a glance, which class of cataract he has to deal with and how it will behave. For instruction on this point I advise him to see Major Smith's book, which is coming out shortly, as space forbids me to go into it here.

I strongly recommend any one commencing to practise this operation to spend some time with a surgeon who has a large clinique and to acquire his knowledge practically, which, in my opinion, is the only satisfactory way. The knowledge doubtless can be acquired by an intelligent operator by actual experiment; such a course is, however, fraught with danger to the patient. This is obvious when we read of the experiences of operators in America, and elsewhere, who have tried this operation without a full practical knowledge of the details. It does not surprise me at all that they condemn it and give it up. I admit at once that the operation is more difficult to learn, and more dangerous to the patients, in the hands of a beginner than is the ordinary operation. I consider, however, that in the hands of an experienced operator the freedom from complications, the avoidance of a secondary operation and the better vision obtained are of such importance as to render it the ideal operation. When the fact that immature cataract can be operated on at any stage, with absolute safety, is taken into account, thereby saving patients sometimes years of weary waiting and, as sometimes happens, loss of sight, whilst waiting, from glaucoma or other diseases, an occurrence which I have seen several times myself, I think the advantages of this operation are so enormous as to render it the most important advance in ophthalmic surgery since the time of Daviel. To estimate the value of knowing the exact method of procedure in this operation, I may mention that on several occasions, when operating at Jullundur, where both eyes are usually operated on at the same time, I have extracted the lens and had escape of the vitreous; the fact has been pointed out to me that I failed to modify the technique quickly enough. Major Smith has then operated on the other eye, to show me where I had failed and has had no escape of vitreous at all. Both eyes almost always, if the cataract be of the same degree of maturity, behave in the same manner in this operation. One of the ways in which escape of vitreous occurs and may be prevented is in the operation for fairly immature cataracts. These cataracts are usually extracted by dislocating the upper edge first, which comes first through the wound. The operator, by pressure directed backwards, dislocates the lens and keeps the pressure up, but the lens does not come out. If the pressure be continued, as it must be, and the lens does not emerge, vitreous may appear above the upper edge of the lens. If when the vitreous is seen in this position, the pressure be still kept up, but its direction instantly changed so as to cause the lens to be carried upwards and its posterior surface to pass over the posterior edge of the incision, the escape of vitreous will be averted. Escape of vitreous occurred in this way two or three times to me whilst operating before I learned to modify my technique instantly so as to avert it. Sometimes the manœuvre has to be combined with counterpressure with a flat spoon above the wound. It is by slight variations of technique, such as this, which are carried out by the experienced operator almost automatically, that the various difficulties which arise are overcome and escape of vitreous and other accidents are avoided in this operation. The operator who is able to anticipate the various modifications of technique required, in the course of the operation, is the one who will have the best results. If in doubt as to how a particular cataract should be extracted, my opinion is that the safest way to proceed is to see if the lower edge of the lens can be dislocated first, and the cataract made to turn over and come out with the lower edge first. This is done by pressing with the

strabismus hook over the lower third of the cornea with a moderate pressure, the direction of the pressure being towards the patient's feet. If the lens is going to turn over, the lower edge will be seen commencing to dislocate and should not be hurried.

As it dislocates, the pressure with the hook should be changed to the upward direction, and the lower edge of the lens be followed up, to help it out and prevent its falling back again.

If, however, it is not going to turn over, and the upper edge of the lens dislocates first, the direction of the pressure should be immediately carried backwards and upwards following up the lens as it passes out through the wound. It is the failure to instantly change the direction of the pressure, and to modify its degree, which accounts, so often, for escape of the vitreous and bursting of the capsule in this operation.

The importance of quickness.—I think it is very important, if the patient be very nervous, and particularly if a woman of the higher classes in India who are I find usually very nervous, to extract the cataract as speedily as possible. I find I am most liable to get escape of vitreous in this class of case. It has occurred to me several times whilst extracting one of the large white looking mature lenses, which have to be extracted lower edge first, as previously mentioned, that all has gone well till the slow pressure of the lens turning over, has pressed on the iris.

Pain results, the patient strains, and if care is not taken vitreous is very apt to be squeezed out, or the lens capsule to burst. I think the two best ways of guarding against these occurrences in this class of case are :—(i) To be sure you have a large enough incision. In a patient likely to give trouble I take care to give plenty of room for the lens to slip out easily. If the incision be made a shade larger than usual the lens comes out more quickly,—a very desirable thing in patients with small self-control. (ii) I have lately given chloroform in these cases. I was led to try it first by having a "purdah nashin" woman, of a highly nervous type, brought to me for operation. Her other eye had been unsuccessfully operated on by the ordinary operation elsewhere. I concluded she had behaved badly at the time of operation, and that she would do so for me. I decided to give chloroform.

I had no difficulty and the case did perfectly. I think I should have not succeeded so well without chloroform. This case led me to try it in others of the same class, with equally good results. I have done too few to be able to come to a definite conclusion, but I think it merits further trial. I put the patient fully under, completing all preliminary preparations as she is going under. I operate the moment anæsthesia is complete. The eyes are usually turned up, but this does not cause the least difficulty in this operation. The patient soon comes round, and usually is allowed to go to sleep if possible, as, if he does, there is less liability to vomiting, I find. He should of course be carefully watched till the anæsthesia passes off. I am fully aware of the increased danger of intraocular hæmorrhage from vomiting and do not advocate its general use, but it has been of great service to me in the class of case mentioned, and I mention it for that reason.

Iridectomy.—I prefer always to do an iridectomy. The skilful performance of the iridectomy is of special importance in this operation, as you have a large wound and greater liability of the vitreous to escape consequently. The iris should be very lightly caught, in fact scarcely held at all by the forceps, as it is a sticky membrane and adheres to the forceps. If squeezed, the patient is very liable to strain and force out the lens or vitreous, or both. The edges of the iris are rather liable to prolapse, even when they have been carefully replaced, owing to the large wound. This may be suspected if the patient complains of excessive lachrymation when the eye is dressed. If very small it may be left alone, but, if large, the eye should be cocainised, and gently washed out with boracic lotion. The upper lid should be raised by an assistant by means of a strabismus hook and the projecting piece of iris snipped off with a sharp scissors. The lachrymation will soon cease if this be done and the eye will settle down and give no further trouble.

THE AFTER-EFFECTS OF ESCAPE OF THE VITREOUS

During the Operation of Extraction of Cataract in the Capsule by Smith's Operation.

By Capt. A. E. J. LISTER, M.B., B.S. (LOND.), F.R.C.S. (ENG.), I.M.S.

In the various discussions which have taken place, from time to time, as to the advantages and disadvantages of this operation, it has been contended by the opponents of the operation for the extraction of the cataract in the capsule that one of the chief objections to this operation is the frequency of the escape of vitreous. This being the only complication which is at all frequent, and the one which is most commonly met with by beginners in this operation, I enquired from Major Smith, on my arrival in Jullundur in 1906, if any series of cases had ever been published in which the after-effects of escape of vitreous in this operation were given. Major Smith informed me, that, as far as he was aware, no such series of cases had ever been published, either after this or the capsulotomy operation.

I then offered to undertake a research into the subject and received permission from Major Smith to make

every use of his hospital records, which were placed at my disposal for this purpose.

Every assistance was rendered me by Major Smith, whom press of work alone had prevented from carrying out this work before. Many thousands of cases in the operation books were gone through and the names of patients in whose eyes escape of vitreous had occurred were noted. Each patient was then written to, and of them 95 presented themselves for examination. In certain of the tables it will be seen that the amount of vitreous and the remarks made at the time of operation are not given. The reason of this is that in the operation book a note only was made of the fact that vitreous had escaped, the details are noted by Major Smith on the patients' tickets always under four headings :—

(i) Drop = 2 to 4 minimums.
(ii) Trace = 4 to 5 ,,
(iii) Slight = 5 to 10 ,,
(iv) Some = 10 minimums to one-third of the vitreous.

The cases will be found classified in the tables appended under these headings.

As the cases went back as far as nine years, it is not surprising, considering the many thousands of hospital tickets there were, that all the tickets could not be found. Native patients are very apt to take tickets, home with them when they go, and in a large hospital with many hundreds of patients and a very small staff, such as there is at Jullundur, it is not always possible to prevent this. Some patients being satisfied with their condition do not wait to be discharged but depart, taking the tickets with them. These facts are well known to surgeons in India, but they are mentioned to make the matter clear to those who do not know India. Three were found to have had escape of vitreous in both eyes, so the number of eyes examined was 98. In 90 of these cases no portion of the capsule of the lens was found to remain ; in 8 a portion of it or the whole was found to be present.

Method of Examination.

The vision of the patients was tested by Snellen's test types, if they were able to read ; in the case of those unable to read, who formed the bulk of the cases, by groups of dots which they were asked to count. Special test cards, with dots of various sizes, corresponding to Snellen's distant test types, were kindly supplied for this purpose by Messrs. Lawrence and Mayo of Calcutta. I found it more convenient to cut out various groups of dots, and to mount them on cardboard, one or two for each corresponding line of Snellen's test types. When dealing with patients lacking in education and advanced in years this plan will be found an advantage. I have many times tested the results given by the same people when asked to read the Snellen's test types. I find that on the whole the dots are slightly the harder test of the two, so that all the results given may be taken as absolutely correct.

I found the use of these dots more convenient than Landolt's optotype, which I also used for some cases. At first I endeavoured to test the vision with the glasses found by determining the refraction of each case by retinoscopy. I found after doing a number of cases that the astigmatism was scarcely ever over one dioptre, so to save time I gave up doing a retinoscopy in every case, and gave them the plus lens they preferred, which in almost every case was a plus ten dioptre lens. The excellent results obtained proved the correctness of my observations, as the results obtained were all without the use of cylindrical lenses. I have noted in the column of remarks the cases in which a spherical lens other than + 10·0 D. was preferred.

The patients in most cases insisted on returning the day they arrived, so that on account of press of work, I was unable to do a retinoscopy in the majority of the cases. As excessive astigmatism has been alleged to be caused by this operation, it may be well to call special attention to these facts. I have also observed a number of cases in which escape of vitreous had not occurred, and I found that in them also the average astigmatism was one dioptre. Owing to enforced absence on several occasions, twenty-five of the cases were kindly examined for me by Major Smith. I had also the advantage of the opinion of Major Smith on the few cases in which disease of the fundus was present, which will be mentioned later. The chief facts revealed by this research are as follows :—

The total number examined was 98. In no case was any detachment of the retina present. Disease of the fundus was found to be present in 8 eyes. A detailed account of these is given elsewhere in this paper. The exact time which had elapsed since the operation was known in every case. It averaged 5·706 years. The different periods since the time of operation ranged from six months to nine years.

Vision of Cases.

Tables will be found at the end of the paper giving the exact vision of each case, with one exception, in which by an oversight I forgot to note it at the time of examination. It may be wondered why the vision of the cases in table " A " do not quite correspond with those in table " B ", being in the form shown chiefly as $\frac{6}{6}$; the answer is that at first I did not test a patient further if he had a vision of $\frac{6}{6}$. Later when I found what excellent vision they had, I endeavoured to estimate it exactly. It will be noted that the average standard of vision is very high indeed, thus in 61 cases in which there was no opacity of the cornea, capsule left behind or disease of the fundus will be found that the vision was as follows :—

$$\frac{6}{3} = 4,\ \frac{6}{3·5} = 6,\ \frac{6}{4} = 4,\ \frac{6}{4·5} = 5,\ \frac{6}{5} = 4,$$
$$\frac{6}{6} = 33,\ \frac{6}{8} = 2,\ \frac{6}{9} = 3.$$

I may remark here that I find in India, owing to, I think, the better light and clearer atmosphere, the patients who come to me for examination usually read a line or two more of the Snellen's test types than they do in England. I find very many British soldiers read $\frac{6}{3·5}$ quite readily This may account to a certain extent for the excellent vision of these cases but it is not the chief reason, which

is the absence of an after-cataract, leaving a perfectly free pupil and also the low degree of astigmatism. An important question is, does the amount of vitreous lost exercise a marked effect on the vision obtained by the patient. The figures at my disposal are too small to admit of any definite conclusion, but they indicate, as far as they go, that it does not have any marked influence. Reference to the tables shows it does not appear to have any marked influence. Thus we find in five cases in which the largest amount of vitreous is lost, the vision was :—

$$\frac{6}{3}, \frac{6}{5}, \frac{6}{6}, \frac{6}{6} \text{ and } \frac{6}{9}.$$

Taking six cases classed as Trace and Slight in which an average of double the amount of vitreous was lost as in these cases we find the vision to be $\frac{6}{3}, \frac{6}{3{\cdot}5}, \frac{6}{5}, \frac{6}{6}, \frac{6}{8}, \frac{6}{9}$. The number of cases is far too small to be conclusive, but they are sufficiently striking to point out the need of further investigation on this point. Thus it does not appear from these cases that the amount of vitreous lost, provided that the eye recovers from the immediate result of the operation, is the important factor in determining the ultimate vision of the patient that might be expected.

I repeat that the number of cases is too small to be conclusive but they are sufficiently striking to call for further investigation. Those operators, who have observed cases in which a large amount, *i.e.*. more than one-third of the vitreous has been lost, will have noticed that the vision of such patients is often much worse at the time of leaving hospital, than the vision of those patients in which a smaller amount has been lost. I have had opportunities of observing these patients in a number of cases after leaving hospital, and have come to the conclusion that their vision is eventually much better than one might expect at the time of their leaving hospital; this observation is in accordance with the above facts, and will be of interest to those who may be intending to adopt the operation of extraction in the capsule. I think it is due to the greater distortion of the cornea which results temporarily, and to the fact that the normal tension and conditions of circulation and nutrition of the eye take longer to be re-established after loss of the vitreous than when it is not lost. I have noticed this to be particularly the case in very old and feeble patients. This fact may have led Ophthalmologists who have not had the opportunity of seeing cases, in which escape of vitreous had occurred, at a time when the eye has had sufficient time to completely recover, to regard escape of vitreous as more serious than this paper tends to prove it to be.

Cases in which Disease of the Fundus was Present.

In 8 eyes of the 98 cases examined, disease of the fundus was found to be present. It may be of use to future observers to mention these in detail. They will be found in table "E," I will proceed to make a short comment on each :—

Case 1, *Table* "*E.*"—Is one of syphilitic disease of the fundus and needs no comment.

Case 2, *Table* "*E.*"—Presents the ordinary history and signs of malarial optic neuritis. I have seen many cases with a similar history and fundus condition. Major Smith says it is quite common in the Punjab and my smaller experience coincides with this.

Case 3, *Table* "*E.*"—Is an ordinary case of disseminated choroiditis. As it was present in both eyes, and escape of vitreous only occurred in the right eye, it cannot be attributed to escape of vitreous fairly. To discuss the question fully as to whether the condition of the fundus was caused by the extraction of the lens in its capsule, as may be suggested by the opponents of this operation, is beyond the scope of this paper. I will only say in passing I do not think it was. Disseminated choroiditis is so commonly seen in the Jullundur clinic, that I do not see any reason to connect it with the operation.

Cases 4, 5, and 6.—These were all cases in which the lens had been previously "*Couched*" and presented the typical appearance of the condition which always follows couching of the lens. This condition has been described fully in the medical press by Major Smith. It is interesting to note, however, that apparently in some cases at least removal of the lens does not prevent the progress of this serious condition.

Case 7.—Is a case of bilateral optic atrophy. Escape of vitreous occurred in one eye only, so it could not have been the cause of the condition in one eye and it is reasonable to assume it did not cause it in the other.

It may be said that the optic atrophy was caused by the operation for extraction of cataract in the capsule, in both eyes. The disease is such a common one in the Jullundur clinic in old men, that I think it is quite as reasonable to say it was unconnected with the operation as with it. This matter needs a separate investigation. It should however be noted here, in connection with this and the preceding case, that Major Smith always extracts a cataract if there is any hope of improving the vision for a time and that the condition may have been present in its earliest form at the time of operation.

Case 4.—The condition may possibly have been caused by the escape of vitreous, but when the fact that the eye was operated on five years before and that the vision was $\frac{6}{15}$ when seen, it seems (taking into consideration the fact that in no other case in the series has any effect been proved to have followed escape of the vitreous) that it is quite as likely to have had another cause. On examining these cases critically it will appear that the case men-

tioned last, Case 3, table " E " only may be due to escape of vitreous.

This condition, however, I have seen so commonly in the Jullundur clinic that I do not regard it as being due to loss of vitreous. Major Smith shares this opinion. I, however, leave the truth of this opinion for other observers to prove or disprove. It may be argued that the cause of some of these conditions may, if not loss of vitreous, be due to the disturbance of the conditions of the eye caused by the extraction of the cataractous lens in the capsule. This argument, I think, can only be advanced as regards cases Numbers 3 and 4 ; optic atrophy and disseminated choroiditis are very common conditions in patients attending the Jullundur clinic and I regard these cases as attributable to ordinary causes, but on this point also further investigation is required. We arrive therefore at the conclusion that of the series of 98 eyes examined one case of retinal degeneration may possibly be due to loss of vitreous, or to the operation of extraction of the cataractous lens in the capsule or to a combination of the two, and that one case of optic atrophy and one disseminated choroiditis may possibly be due to extraction of the cataractous lens in the capsule. If we take the escape of vitreous occurring during this operation as being about 5 to 6 per cent. in the hands of skilled operators, and allow that one case out of every 98 in which this accident happens develops subsequent disease of the fundus, we arrive at the conclusion on the foregoing facts that loss of vitreous in this operation, provided the eye recovers from its immediate effects, is not the serious complication which it at first sight appears. It is interesting to note that this is the opinion arrived at by Major Smith from a general experience of these cases, apart from any definite research in this subject, some years ago.

It is specially interesting to note that detachment of the retina, the condition so generally feared as liable to occur after escape of the vitreous, did not occur in a single case. I suggest in conclusion that those ophthalmologists who regard loss of vitreous as such a serious accident in cataract operations have been guided by the facts as known to them in operations other than the intra-capsular one. It is quite probable that the eyes in these operations, hampered with debris and the capsule of the lens, which, apart from those cases in which definite iritis occurs, must usually cause some degree of irritation, do suffer more serious damage when loss of vitreous also occurs than does the eye which is free from any irritating material. The fact that, in the eight cases in which capsule was left, there was disease of the fundus is interesting, but it should be remarked that in only one case was there a large amount of capsule, *i.e.*, case number ten, Table C.—the other cases having only a small amount as Major Smith always endeavours to remove as much of it as possible. On account of having a large wound, it is possible to remove most of the debris so that the condition in these cases was not quite the same as it is in the ordinary capsulotomy operation.

Having regard to the facts given here, I maintain that though the number of cases is far too small to be conclusive it is sufficiently large to make us hesitate before we accept any conclusions formed by ophthalmologists who do not extract cataract by Smith's operation as to the seriousness of loss of vitreous in this operation. Further investigation will doubtless throw more light on this important subject. I repeat, however, let us be careful before we accept any dicta by any ophthalmologist, however distinguished he may be, on this important subject, unless supported by a series of cases, an account of the operation performed, especially a statement as to whether the capsule was left behind or not, and if iritis or iridocyclitis followed.

TABLE A.

Showing—

(1) Number of years since the operation.
(2) Vision.
(3) Amount of escape of vitreous.
(4) Astigmatism.
(5) Remarks noted on case sheet at time of operation.
(6) Notes on points of interest in brackets in last column.

Number of cases—36.

Number.	Name.	Years since operation.	Vision.	Amount of Escape of Vitreous	Astigmatism.	Remarks at time of operation.
1	Khara ...	5	6/9	Trace ...	...	Iridectomy.
2	Akho ...	4	6/18	" ...	...	Iridectomy. "Very Nervous."
3	Harnam Singh.	5	6/36	Trace ..	...	Iridectomy. Lens lifted on spoon.

Number.	Name.	Years since operation.	Vision.	Amount of escape of vitreous.	Remarks at time of operation.
1	Kara ..	6	6/6	Slight ...	Slight escape of vitreous. No iridectomy. He shot out lens and some vitreous on completion of incision from nervousness.
2	Bhagwani ...	2	6/36	" ...	Iridectomy. Lens extracted on spoon.
3	Dani ...	5	6/36	" ...	No iridectomy.

Number.	Name.	Years since operation.	Vision.	Amount of escape of vitreous.	Astigmatism.	Remarks at time of operation.
1	Mammon ...	1	6/6	Drop ..	......	Iridectomy.
2	Fata ...	1	6/36	" ...	......	Do.
3	Tabo ...	1	6/6	" ...	... ..	Do.
4	Deva Ditta...	2	6/6	" ...	......	Lens dislocated by " Rawal."
5	Jhandoo ...	7	6/6	" ...	......	Iridectomy.
6	Fateh Din ...	5	6/3·5	" ...	+ 0·75 D cylinder.	Do. Very nervous patient.

Number.	Name.	Years since operation.	Vision.	Amount of escape of vitreous.	Astigmatism.	Remarks at time of operation.
7	Achroo ...	1	$\frac{6}{4\cdot5}$	Drop ...	...	Iridectomy.
8	Mosaddi ...	2	$\frac{6}{6}$	" ...	+ 0·75 D cylinder.	Do. (*Note.*— Left eye operated on by Rawal. Never saw well with it. Now only sees hand movements).
9	Sharo ...	5	$\frac{6}{4}$	" ...	......	Iridectomy.
10	Atra ...	1	$\frac{6}{6}$	" ...	......	Lens expelled on completion of incision with drop of vitreous.
11	Kalo ...	2	$\frac{6}{3\cdot5}$	" ...	......	Iridectomy. Vision $\frac{6}{3\cdot5}$ obtained with + 9·5 D.
12	Bhagwana ...	6	$\frac{6}{6}$	" ...	+ 0·75 D cylinder.	No iridectomy. (Vision $\frac{6}{6}$ with +9·0 D Sp. + 0·75 cylinder.)
13	Ranji Das ...	2	$\frac{6}{5\cdot5}$	" ..	......	Iridectomy. (Cornea slightly hazy from old Trachoma above.)
14	Ako ...	$1\frac{1}{2}$	$\frac{6}{5}$	" ...	+ 1·25 D cylinder.	Iridectomy.
15	Ganda ...	1	$\frac{6}{6}$	" ...	......	Iridectomy. Vision $\frac{6}{6}$ with +9·0 D lens.
16	Ganpat ...	2	$\frac{6}{6}$	" ...	+ 0·75 D cylinder.	Iridectomy (Vision $\frac{6}{6}$ with + 9·0 D Sp. + 0·75 cylinder.
17	Daswandhi...	7	$\frac{6}{3\cdot5}$	" ...	......	No iridectomy.
18	Inchri ...	1	$\frac{6}{6}$	" ...	......	Iridectomy.
19	Biro ...	1	$\frac{6}{9}$	" ..	......	Iridectomy. Lens extracted on spoon. Very bad patient.
20	Hukram ...	1	$\frac{6}{4\cdot5}$	" ...	......	Iridectomy.
21	Jamal Din	6	$\frac{6}{4\cdot5}$	" ...	......	No iridectomy.
22	Natha ...	2	$\frac{6}{4}$	" ...	......	Iridectomy.
23	Gangoo ...	5	$\frac{6}{5}$	" ...	+ 1·25 D cylinder.	Iridectomy. Very nervous patient.
24	Raman San .	7	$\frac{6}{3}$	" ...	......	No iridectomy. (Vision $\frac{6}{3}$ with + 9·0 D Sp. lens.)
25	Harnam Singh.	7	$\frac{6}{4\cdot5}$	" ...	......	No iridectomy.

Number.	Name.	Years since operation.	Vision.	Amount of escape of vitreous.	Remarks at time of operation.
1	Mamon ...	2	$\frac{6}{3}$	Some ...	No iridectomy. Lens expelled with some vitreous on completion of incision.
2	Rahmat Ali..	1	$\frac{6}{6}$	" ...	No iridectomy. Lens expelled on completion of incision with some vitreous.
3 & 4	Gulaba (Two eyes).	6 ms.	$\frac{6}{5}$	"	
5	Harnam Singh.	1	$\frac{6}{9}$	" ...	Iridectomy. Lens extracted on spoon. Very bad patient.

Table B.

Showing—

(1) Number of years after operation.
(2) Vision.
(3) Astigmatism.

Number of cases—25.

Number.	Name.	Years after operation.	Vision.	Amount of escape of vitreous.	Astigmatism.	Remarks at time of operation.
1	Hira Singh...	1	$\frac{6}{4\cdot5}$	Unknown..	+ 0·75 D cylinder.	
2	Mirau Bux...	$7\frac{1}{2}$	$\frac{6}{6}$	"	......	
3	Ghulam Haider.	7	$\frac{6}{8}$	"	+ 0·75 D cylinder.	
4	Roha ...	$4\frac{1}{2}$	$\frac{6}{6}$	"	+ 1·25 D cylinder.	
5	Mohammed Din.	1	$\frac{6}{6}$	"	......	
6	Roda ..	6	$\frac{6}{6}$	"	......	
7	Omra ...	2	$\frac{6}{6}$	"	......	
8	Mali... ...	$5\frac{1}{2}$	$\frac{6}{6}$	"	......	
9	Devi Ditta...	3	$\frac{6}{6}$	"	......	
10	Ghanja ...	5	$\frac{6}{6}$	"	......	
11	Badh Singh...	9	$\frac{6}{6}$	"	......	
12	Kaka Shah..	6	$\frac{6}{3\cdot5}$	"	+ 0·75	
13	Iddoo ...	6	$\frac{6}{6}$	"	+ 0·5	
14	Shah Din ..	$7\frac{1}{2}$	$\frac{6}{6}$	"	+ 0·5 D cylinder.	
15	Mehtab Singh.	$5\frac{3}{4}$	$\frac{6}{6}$	"	+ 0·75 D cylinder.	
16	Mamon ..	7	$\frac{6}{6}$	"	+ 0·5 D	
17	Dania ...	3	$\frac{6}{6}$	"	......	
18	Hakko ...	4	$\frac{6}{6}$	"	......	
19	Mammond ...	2	$\frac{6}{6}$	"	......	
20	Abdulla ...	2	$\frac{6}{6}$	"	......	
21	Juna ...	$3\frac{1}{2}$	$\frac{6}{6}$	"	......	
22	Naonid ...	4	$\frac{6}{6}$	"	......	
23	Tabo ...	$3\frac{1}{2}$	$\frac{6}{6}$	"	......	
24	Edoo ...	$6\frac{1}{2}$	$\frac{6}{6}$	"	......	
25	Shadi ...	3	$\frac{6}{6}$	"	......	

Table C.

Cases in which opacity of the cornea was present.
Showing—(1) Number of years since the operation.
(2) Vision.
(3) Amount of escape of the vitreous.
(4) Notes made on case sheet at the time of operation.
(5) Notes on points of interest in brackets in the last column.

Number of cases—10 (9 patients, 1 double).

Number	Name.	Years since operation.	Vision.	Amount of escape of vitreous.	Remarks at time of operation. (Notes in brackets.)
1	Nathu ...	7	$\frac{6}{9}$	Drop ...	Iridectomy.
2	Sabho Davia	5	$\frac{6}{8}$	Do. ...	Iridectomy.
3	Hurkan ...	4	$\frac{6}{12}$	Do. ...	Iridectomy
4 & 5	Gulaba ...	6ms.	$\frac{6}{12}$	Some ...	No iridectomy.
6	Harkan ...	5	$\frac{6}{12}$	......	......
7	Suchet Singh.	1	$\frac{6}{15}$	Drop ...	Lens extracted on spoon.
8	Jhandoo ...	6	$\frac{6}{15}$	Do. ...	Iridectomy—Nervous patient.
9	Hakam Singh.	1	$\frac{6}{18}$	Do. ...	Iridectomy.
10	Ramai Dai...	6ms.	Counts fingers at one yard	Do. ...	(Cornea opacity very marked, caused by small-pox.)

Table D.

Cases in which the capsule of the lens was left behind, owing to bursting at the time of operation.
Showing—(1) Number of years since the operation.
(2) Vision.
(3) Amount of vitreous escape (six cases only).
(4) Remarks noted on case sheet at time of operation.
(5) Notes on points of interest in bracket in last column.

Number of cases—8.

Number.	Name.	Years since operation.	Vision.	Amount of escape of vitreous.	Remarks at time of operation. (Notes shown in brackets.)
1	Ako ...	6 mos.	$\frac{6}{5}$	...	(Capsule needled previously.)
2	Ahmad Khan	$1\frac{1}{2}$	$\frac{6}{6}$	Drop ...	No iridectomy.
3	Nihala ...	$4\frac{1}{2}$	$\frac{6}{8}$	...	
4	Natha ...	5	$\frac{6}{15}$	Drop	
5	Ahmed ...	6	Not noted by error.	,, ...	Drop of vitreous taken out of right eye on account of tension.
6	Diwan Singh	2	$\frac{6}{12}$	,, ...	Iridectomy.
7	Gaunsa ..	6	$\frac{3}{60}$	,, ...	No iridectomy.
8	Shib Dial ...	1	Counts fingers only at 2 yards.	Some ...	Iridectomy. (Dense after cataract seen.)

Table E.

Detailed notes on eight cases (seven patients, one double).

Cases with diseased condition of Fundus.

Case 1.—Name, Bago. Operated on $1\frac{1}{2}$ years ago. "Drop" of escape of vitreous in both eyes—both extracted on spoon. Vision = $\frac{6}{18}$. States that he had very poor vision in both eyes before cataract developed. Had syphilis. On ophthalmic examination signs of old neuro-retinitis.

Case 2.—Name, Para Singh. Operated on five years ago. Vision can only count fingers. Sight was all right for two years after operation. Then had high fever with delirium. Pupillary reaction very sluggish. Disc pale. Retina atrophied, probably caused by malarial optic neuritis.

Case 3.—Utman Dai. Operated on one year ago. Vision can only see hand movements. Both lenses well extracted in the capsule with a "drop" of escape in the right. Disseminated choroiditis seen in both eyes on ophthalmoscopic examination.

Case 4.—Edoo. Operated on five years ago. "Trace" of escape of vitreous in right eye. Left eye lost previously from trachoma. Vision = $\frac{6}{15}$. Very stupid old man. Could give no clear history of his condition. Retina presents appearance of retinitis. Pigmentosa sine pigmento in an early stage.

Case 5.—Ram Singh. Operated on $1\frac{1}{2}$ years ago. The right lens is noted as having been previously dislocated by the "rawal" or lens coucher at the time of operation. It was noted also as having been expelled on completion of the incision with a "drop" of vitreous. Note made "bad patient." Vision = $\frac{6}{15}$. On ophthalmoscopic examination the typical condition of retinitis pigmentosa sine pigmento, which always followed couching of the lens.

Case 6.—Name, Hako. Operated on two years ago. Vision *nil*. "Drop" of escape in the left eye. Lens noted as dislocated at the time of operation. The same fundus condition as is Case No. 5 but more advanced.

Case 7.—Name, Khuda Bux. Age 60. Operated on $4\frac{1}{2}$ years ago. Escape of vitreous in one eye only, amount not noted. Both lens extracted in the capsule. Primary optic atrophy in both eyes.

DISCUSSION.

Major Kilkelly, I. M. S. (Bombay), wittily remarked that the papers read were only from members of one school—the Jullundur school. As for his ownself, he was no opponent of the intra-capsular operation, and formed a class by himself, selecting one or the other method as the particular case required. But

the object was to find out a universal method. Lieut.-Col. Herbert's statistics are as good as those of the Jullundur school. He had done about 500 intra-capsular operations, but the results did not seem satisfactory, and so he had given up the operation. May be that he was wrong in some technique, as he had never seen the intracapsular operation done. But his results with the capsulotomy method were as good as Major Smith's. The only drawbrack that he considered was iritis. Vitreous escape is not dangerous, even when enormous, as he had in one such case found the vision subsequently to be 5/6.

He wondered as to how the spoon, "on which the lens is to be supported" can be introduced when the eye is rotated upwards.

Major Heard remarked on the peculiar elongated pupil which results from the wide iridectomy as required by Major Smith's operation, suggesting that a smaller iridectomy would be better. Perhaps be added, the advantage of a wide iridectomy is "less instrumentation."

Dr. Prabhaker (*Bombay*).—India is the land of cataracts; therefore we should once for all decide the method which must be the method for the future. The new operation has the advantage of doing away with the drawbacks of the old method: suppuration and iritis. A surgeon of to-day need not fear a big incision, when he has fully studied asepsis and antisepsis; whilst, with the old method, the surgeon has for the first four or five days to constantly fear iritis, not to speak of the subsequent operation of needling and the resulting poor vision. The new method carries with it only two disadvantages —detachment of the Retina, and escape of vitreous. But these supposed dangers prove to be no more real as seen from the papers read. He, having been accustomed to the old method, would not like to take up the new one; but as the point was to settle for the "future," he would recommend the intracapsular method

Major V. Bennett, F. R. C. S., I. M. S (*Bombay*).—The Punjab surgeons seem without doubt to have established their contention that Smith's operation is the ideal operation, in the Punjab and such climates. But we must remember that when this controversy was raging in the Indian Medical Gazette, the three ophthalmic surgeons of Calcutta, Madras and Bombay were opposed to it. It is absurd to say that surgeons such as these disapprove of the operation because they do not know how to do it. In fact, one day when I was watching Major Herbert operating, he pointed out a case on the table as being a suitable one for extraction in the capsule: and he then proceeded to do that operation with a perfect result. We must therefore seek some other reason for the fact that the belief in Smith's extraction in the capsule has not been received with full approval outside of the Punjab. The Punjab surgeons support their assertions by the records of thousands of cases, and this large number of cases seems to give the clue. To produce this large number of cataracts some specific cause must be at work in these climates. And for those cataracts only which are produced by this specific cause, which does not act in other climates, Smith's operation is the ideal one.

Dr. W. Wanless, M. D. (Miraj).—The Punjab school has proved its points; but the intra-capsular operation should not be undertaken by any one without enough practice. Of the 3,000 cases done by me, 300 were intra-capsular, and I prefer it on the whole, but only in selected cases. It requires great skill and a good assistant. To make it a routine method is dangerous.

Dr. Wallace.—The point to decide is what is the operation for an average operator, because experts of the two different schools give equally good statistics. I agree with Dr. Wanless in the necessity of enough practice and a good assistant. Application of Tinct. Benzoin to the upper lid enables the assistant to keep up the lid. Wide iridectomy facilitates the operation to a great extent. That iritis is not a complication I do not believe; because when the capsule is removed the exudate remains in the angle of the anterior chamber, thus hiding the iritis. In fact I have seen cases complaining of pain, with redness of the eye, and still said not to have iritis.

Dr Arthur Neve, F.R.C.S.(Kashmir).—It is to be regretted that the discussion is only one-sided in the absence of such weighty adherents of the "Old School" as Herbert, Elliot, Maynard and others whose opinions are entitled to the highest respect. I have been as a pupil to Jullundur, but cannot claim to have graduated in "Smith's School"; I would emphasize the desirability of men going to him to learn the minutiæ of the technique which are certainly difficult for the assistant as well as the operator; and I would strongly deprecate young surgeons trying this "complete" extraction until they had an experience of at least 50 capsulotomy cases, as I have seen disastrous results in rash hands. With regard to the wide iridectomy criticised by Major Heard, it was Col. Roberts of Indore who first impressed upon me the degree to which a wide iridectomy facilitates extraction; and being upwards it causes no noticeable defect afterwards. It can be scarcely claimed that there is *no iritis* after extraction in the capsule. I have seen many red watery eyes with tenderness due to inflammatory reaction; but the signs of iritis were different after the capsule had been removed; any plastic exudate would no longer invade the pupil, passing along the capsule, but would be confined to the angles of the anterior chamber. I think excessive pressure causes prolonged irritability in the eye. A drop of Tinct. Benzoin Co. applied to the upper lid helps the assistant's finger in gripping and controlling the orbicularis. It does not follow that the best operation for the Punjab peasant anxious to get home to his field in a week is the best operation for all; there are those who would wait for needling.

J. Rutter Williamson, M. D. (Poona), remarked that speaking from personal experience he felt sure many like himself had thought that they were performing Smith's operations, but learned, after seeing Smith perform it, that there was a large number of important details of which they were previously ignorant, and which went to make up its success. He asked what those present had found the best treatment for the striped descemitis which in his experience appeared to be more common after the intracapsular than the capsule laceration operation. Dionin usually did good, but occasionally one saw cases which left hospital with some obscurity of cornea remaining.

Major H. Smith (*Jullundur*).—I may be permitted to reply for Capt. McKechnie, Capt. Lister and Dr. Kidar Nath who are absent and to touch on a few points in general. It has been advanced that skilled operators of the two schools get equally good results; surely no one will class Dr. Jamieson's, Capt. McKechnie's and Capt. Lister's experience as placing them among Indian operators of more than ordinary experience. Place their results alongside of the whole figures of Indian cataract extractions for the year 1906. The reports of all the Indian charitable hospitals for that year were recently before me and I was struck with the close uniformity of results in Province after Province. In the old operation the failures to obtain vision for all causes amounts to roughly about 14 per cent. Put this alongside of the figures advanced for the new operation which amount to a failure in about one per cent. which is in harmony with my own figures of an experience now of about 21,000 cases, and how can it be said that the two operations give equal results? The operators are equally skilled, equally careful, the patients are of the same race and the conditions under which they are operated on are the same. Then as to the quality of the vision obtained there is no comparison. In the new operation without any secondary operation the average vision would be $\frac{6}{6}$ and this goes on improving for some months after operation with vision ranging from $\frac{6}{6}$ to $\frac{6}{3 \cdot 5}$. With the old operation a good average would be $\frac{3}{6}$ on leaving hospital falling to $\frac{3}{12}$ at the end of three months and to $\frac{3}{18}$ at the end of six months. Of course when these latter are submitted to one, two or even three needling operations, which patients Indian and European so much dread, vision is improved considerably but not up to the standard of the intracapsular operation. Then again needling is not the simple harmless operation its advocates would have us to believe. It would, I suppose, be admitted that I have a liberal experience of needling, as I see many cases done by other men, and I regard it as formidable an operation as extraction of a cataract in the capsule. Needling is at best a make shift. It leaves the offending body in the eye and it is far from being a harmless body. What are the causes of this

great relative failure to obtain vision in the old operation? Apart from iritis and irido-cyclitis the great cause is tags of capsule hanging in the wound; when the eye is opened on the second or third day there may appear nothing septic, but a few days later the eye appears to have become infected, the tags of capsule are very reluctant to unite with the wound and form a septic drain. The disinfection of the conjunctival sac at the time of operation may keep it safe for up to even four days but not more. Hence the much vaunted conjunctival flap with its enormous amount of consequent astigmatism in virtue of the fact that it shuts off the conjunctival sac quickly covering up these tags of capsule. In the Intra-capsular operation we can safely make the incision which Capt. McKechnie in his valuable and irrefutable contribution has shewn to be the scientific incision, *viz.*, an approach to a radial incision, one which is followed by relatively trifling astigmatism. I thoroughly agree with the contention of Dr. Jamieson, Capt. McKechnie and Capt. Lister and I have now some experience of teaching experienced operators on cataract. A man may read for years articles on this subject. He may see hundreds of operations done by an experienced operator, put him to do it and it is very noticeable how little he knows.

But when he has done a few under the instruction of a competent operator, it is equally remarkable how quickly he becomes familiar with the technique. It is an art and has to be learned by practice and, best and quickest, by practice under a good instructor. What practical man advocates the learning of any art from a mere book description. A man may learn to do general surgical operations from a book description. In them a trifling error in technique is of little importance. Not so in extraction of cataract in the capsule. Remarks have been made concerning the size of the iridectomy necessary in this operation; when vitreous escapes the margins of the coloboma made in the iris have a tendency to be caught in the angles of the wound and so to make the iridectomy look much bigger than is really the case. There is no necessity for an iridectomy in this operation. I generally do an iridectomy simply to avoid prolapses of the iris. There is no difficulty in extracting a cataract in the capsule through an opium pupil without an iridectomy. Atropine is thus not necessary. Dr. Jamieson, Capt. McKechnie and Capt. Lister have shown that this operation can be done with escape of vitreous occurring in not more than from 5 to 6 per cent. of the cases. Five years of the recent statistics of the large Ophthalmic hospital of Bombay city were recently before me and I observe that escape of vitreous occurred in a very small fraction under 5 per cent. of the cases and there is perhaps no operator by the capsulotomy method more skilful than the operator in question. Thus in competent hands the liability to escape of vitreous need not be looked on as more serious in the one operation than in the other. Capt. Lister's paper, I think, should get those who so much dread escape of vitreous to think. Major Bennett refers to a controversy which occurred between Major Herbert, Major Maynard, Major Elliot on one side and myself on the other, when extraction in the capsule was in its infancy, when it was struggling for its existence. That controversy will bear reading to-day on its own merits and especially in the light of the proceedings of this section of this congress. I have no reason to be ashamed of my position in that controversy. The gentlemen on the other side of that controversy had ample opprtunity to be here in person or to be represented by papers. I am sorry they are absent. Col. Herbert's name has been used as an argument against extraction of cataract in the capsule. Let any one read Col. Herbert's book on cataract extraction; the work of a careful and conscientious man and the best chapter on the subject so far written and I think he will come to the conclusion that taken as a whole it is the strongest argument yet advanced in favour of extraction in the capsule.

Major Kilkelly, I. M. S. (Bombay).—I have been doing the subsequent needling on the 8th day after which the patient is discharged; and of the 1,200 cases I know of none having gone bad. Keratitis is fairly common in both methods, and is supposed to be due to folding of Descemets membrane, and did not persist long in my cases.

Capt. Gidney, I. M. S.—It is difficult to make the hard atrophic lens where the nucleus is large to take the somersault, and there is great risk of dislocation in the Vitreous Chamber. Choroidal hæmorrhage, I believe, is due to arterio sclerosis. I have operated without having seen Major Smith actually operating; and have been successful. A corneal incision is more likely to cause vitreous escape, the incision being necessarily small. I am not in favour of chloroform anæsthesia, because of the vomiting it subsequently sets up. Percentage of successes is not the same in the two operations as remarked by Major Kilkelly, as can be seen from the figures in my paper. Eserine, as recommended by Capt. Oxley, has much diminished the percentage of prolapse of iris in my cases.

Capt. Jamieson, I. M. S.—Choroidal hæmorrhage, I think, is due to lowering of tension, and, as nothing more is removed in the new operation than in the old one, it is no contra-indication. Posterior synœchiœ cause no difficulty in the intracapsular method. Eserine prevents prolapse of iris, and helps in improving the shape of the pupil.

Dr. B. H. Nanavatty, F.R.C.S., (Ahmedabad).—The intracapsular method, now brought to perfection by Major Smith, had been practised by Col. J. McCloghry, I. M. S. (then Civil Surgeon, Ahmedabad, and lately Officiating Surgeon-General with the Government of Bombay) and myself so early as 1894-5, in the Civil Hospital, Ahmedabad, as a variation only from the ordinary method. It is really a great advance on the old methods, the great advantage being in connection with an immature cataract, the patient being thus saved the anxiety, worry and inconvenience of waiting. But the great drawback is the requirement of great experience and a well trained assistant. This operation was done by us many a time, but I cannot say why we did not demonstrate its manifold advantages. I merely mention these facts, not with a view to take any credit, which, as a matter of right, deservedly belongs to Major Smith, and his name, I am sure, like those of many other distinguished and earnest workers of that great service—the I. M. S.—will long live in the annals of the civilised world.

ON INCISION OF THE EYE,

WITH SPECIAL REFERENCE TO INCISIONS FOR THE EXTRACTION OF CATARACT AND FOR THE RELIEF OF GLAUCOMA.

By Capt. W. E. McKECHNIE, M.B., CH.B., *Indian Medical Service, Jullundur, Punjab.*

The history of the Extraction of Cataract records that almost every kind of incision it is possible to make has been used at one time or another for the extraction of the lens, and most of these have been abandoned.

It is now 163 years since Daviel inaugurated the operation of cataract extraction, yet, even now, after so long a period, finality of opinion and of procedure has not been attained as regards the incision most suitable for extraction. The matter is therefore worth examining, and is here investigated from four different aspects: the *Mechanical*, the *Anatomical* and *Physiological*, the *Pathological* and the *Technical*.

Mechanical.

Mechanical considerations appear to have been neglected, probably because medical men are not as a rule mathematicians. Yet we are here dealing with a problem which is largely one of mechanics. Here is a body bounded by two spherical surfaces and containing fluid under pressure; and the problem of what will happen when we incise this body in different directions is available for mathematical treatment. Indeed I had no proper idea as to what does happen until I came to investigate the thing mathematically.

The cornea is a spherical cap; the sphere of which it is a part has a radius of 7 millimetres. The base of the corneal cap has a diameter of approximately 11 millimetres. These are internal measurements as we are here only concerned with the internal surfaces of the globe of the eye, because it is on these surfaces that the fluids of the eye exert their pressure.

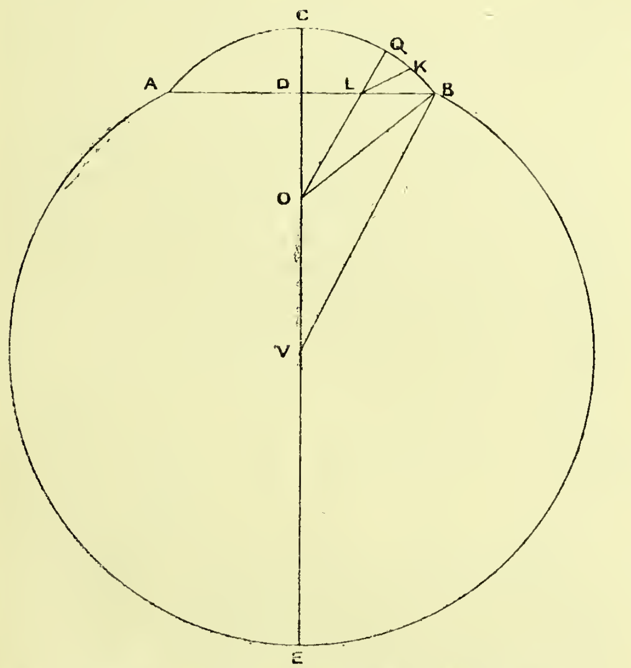


Fig. 1.—*Eye: Antero-posterior Vertical Median Section.*

Arc ACB is internal surface of Cornea in section.

Arc AEB " " " " Sclera " "

AB = internal diameter of Cornea = 11 millimetres.

O is centre of Corneal Sphere, of which OB and OQ are radii of length 7 m.m.

V is centre of Scleral Sphere, of which VB is radius of length 12 m.m.

A and B mark Corneo-Scleral Junction and D is centre of Corneo-Scleral plane.

C anterior pole.

E posterior "

L a point representing a line of puncture and counter-puncture 2·5 m.m. from D: that is, the points of puncture and counter-puncture are on a line parallel to the horizontal meridian passing through the base of the Cornea and 2·5 m.m. from it.

LB the Corneo-Scleral flap incision.

LQ the radial corneal incision.

LK an intermediate corneal flap incision.

Figure 1.—Draw a line AB of 11 units, each unit to represent one millimetre. With A and B as centres and a radius of 7 units draw arcs cutting at O, and with O as centre draw arc ACB of 7 millimetres radius. The sclera has a radius of about 12 millimetres. With A and B as centres and radius of 12 units make arcs cutting at V, and with point V as centre and the same radius draw the arc AEB. Draw a straight line through O and V and produce it each way to C and E. The figure now represents to scale a median section of the wall of the eye. CE is the optical axis, AB the plane of the corneal base or corneo-scleral junction; point O is the centre of curvature of the cornea, and point V that of the sclera.

The eye is a closed vessel filled with fluid; for the vitreous, so far as mechanical considerations here dealt with are concerned, we may regard as a fluid. This fluid is under pressure, which we will denote by P, P being the number of units of pressure per unit area. As the effect of the force of gravity may be disregarded in the case of so small an object as the eye, P is everywhere the same within the globe, owing to the well known property of fluids of transmitting pressure so that any surface in the fluid is pressed upon with a pressure P per unit area in a direction normal or at right angles to the surface. The direction normal at any point in the surface of a sphere is that of the radius of the sphere at that point. The pressure P then per unit area will be exerted uniformly over the internal spherical surfaces of the sclera and cornea in the direction of the radii from V in the case of the sclera and of point O in the case of the cornea. The tangential component of the pressure is zero, because it is equal to P cos $\frac{\Pi}{2}$, and cos $\frac{\Pi}{2} = O$.

The whole force of the pressure on the walls of the eye is thus exterted in straight lines radiating away from the respective centres of curvature of the walls and in no other direction.

Draw the corneal radius OQ cutting AB in the point L, and let L be the site of puncture and counterpuncture for an incision commencing in the corneo-scleral margin.

First suppose the incision to be carried out along LQ. It will be in the plane of a great circle passing through the centre of curvature O; and the arc LQ, the corneal wound, will be an arc of a great circle. What happens? The pressure P of the fluid within the eye acts in the direction of the radius from O. As regards the wound all these radii lie in the plane of the wound LQ. We saw above that the pressure on the surface at right angles to a radius was zero. Therefore there is no pressure on the edge of the wound at right angles to the plane of the incision, and therefore the wound will not gape. If truly linear and not too large, as large size would bring other forces due to the elasticity and tension of the coats of the eye into play, the wound will remain closed and will not allow the fluid within to escape, and P will not diminish.

The outward pressure along the arc of the great circle represented by a lip of the wound will keep the lip in a

state of tension ; and, because the spherical form is that of static stability, the lip of the wound will retain its original shape, that of the arc of a great circle.

What happens then when the section LQ is made is this : the wound does not gape but closes, and retains the fluid within the eye even under pressure. The edges of the wound retain their shape as arcs of a great circle of the corneal sphere, remaining in close opposition and in a state of tension along their lengths, the tension being proportional to the pressure of the fluid within.

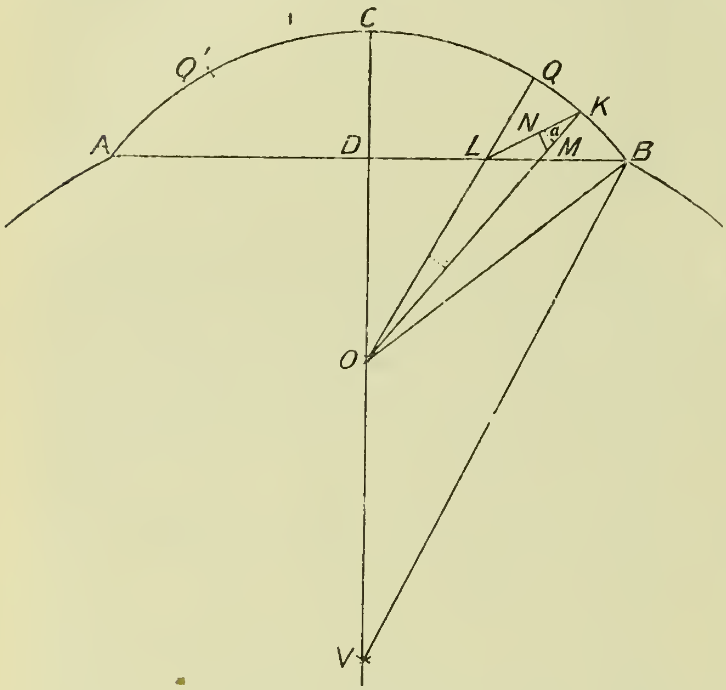


FIG. 2.—*The same as in Fig.* 1.

Point Q the apex of the radial incision LQ.
„ Q' a corresponding point.
QQ' is parallel to AB and is 7 m.m. long.
∴ triangle OQQ' is equilateral and $\angle Q'QO=60°$ and $\angle QLB=\angle QQO=60°$.
MN is perpendicular to LK.
Angle $LKO=\alpha$

Now suppose the knife to cut out in a plane such as that of LK. Refer to Figure 2, which is on a larger scale than Figure 1, but with the same lettering. Join OB, OK, and VB. Let the angle $LKO = \alpha$. If we sum the forces acting along the arc of the wound, KL represents the direction in which the wound lips in tension can pull to counteract the pressure P, which acts along the radii of which, in direction, OK represents the sum. From any point M in OK drop a perpendicular MN on to LK. Then if MK be taken to represent P in magnitude and direction, its components along LK and at right angles to LK will be represented in magnitude and direction by NK and MN respectively. The component of pressure NK leads to a tension KN, which exactly neutralises it. This force KN I will call the *Closing Component*. The component of pressure MN acts at right angles to LK, that is, to the plane of the blade of the knife, and in the direction MN. The lip of the wound towards the A side of LK will therefore tend to move in that direction ; LK will therefore tend to revolve about L till it lies in the direction LQ, in which position the component of pressure MN, which I will call the *Opening Component*, would vanish, and the opening action would cease. Were the segment of cornea LKQ perfectly soft and flexible and were the pressure to be sustained for any length of time, this rolling back would actually happen and the gap QLK would be produced as soon as the incision LK was completed. But as the cornea has a certain amount of rigidity and elasticity, what happens is that the lip on the A side of LK gapes just sufficiently towards the position LQ to allow the internal pressure in the eye to become $P = O$. The lip of LK on the B side is subject to the same opening component MN, but, in this case, having regard to the direction of MN, the *Opening Force* is negative. If the lip were free to move, it would move towards the position LQ, being impelled to do so by the sum of the MN components acting over the surface of the segment between the directions OK and LK ; but it is prevented from moving in the A direction by its attachment in continuity with the rest of the wall of the eye.

Between the planes of OK and OQ we have the total forces represented by NKs and MNs, or Σ NK and Σ MN, and they tend to cause the area LKQ to vanish into LQ, and the area on the B side of LK to expand into LKQ. We thus see that the B side lip will tend to follow after the A side lip which tends to fold back into the position of rest along LQ. We have here a simple and sufficient explanation of the over-riding which takes place during the healing of flap incisions for cataract. When the section is made there is no over-riding because the pressure P has become zero owing to escape of fluid from the eye, and it will remain zero so long as the wound edges do not adhere. When the process of repair causes the edges to adhere the pressure is able to rise within the eye. Then the forces described above begin to operate and, as the material forming the line of union along LK is plastic, it will allow the margin of the wound towards the B side, acted upon by the Σ MN on the B side of LK, to advance slightly towards LQ, whilst the opposite margin of the wound, tending to rise up and gape, will over-ride it. The condition for this then is a plastic healing process in a flap incision, which, whilst sealing the wound and permitting of a development of pressure within the eye, is plastic enough to allow the margins of the wound to slide on one another.

The Closing Component $KN = KM \cos \alpha$: the Opening Component $MN = MK \sin A$. Let K approach Q so that LK approaches to the position LQ. The angle α will evidently diminish. As an acute angle diminishes towards zero its cosine increases and its sine diminishe in magnitude. Therefore as K approaches Q, the closing component $P \cos \alpha$ increases, whilst the opening component $P \sin \alpha$ diminishes, so that the wound has less and less tendency to gape. When LK coincides with LQ the angle $\alpha = 0$ and $\cos \alpha = 1$ and $\sin \alpha = 0$; so that here the closing component, is $P \cos \alpha = P \times 1 = P$; and

the opening component, P sin α = P $\times$ 0 = 0 ; which is the conclusion previously arrived at when discussing the incision along LQ ; this was that there will be no force acting at right angles to the plane of the incision causing the wound to gape but that the whole outward pressure will be exactly met and neutralised by an equal and opposite tension. If K passes Q and proceeds further along in the direction of A the angle α will begin to increase in amount, but in a negative direction; its cosine will not change sign, but its sine will do so ; the closing component remains P cos α but the opening component becomes P sin α with negative sign, that is, it acts in the opposite direction to what it did before. Hence it will be the B-sided lip of the wound which will now tend to gape and roll back, and the A-sided lip to come forward or contract underneath the other. Let us now consider what happens when K moves towards B. The angle LKO or α widens out or becomes larger. Its cosine will therefore diminish and its sine increase, so that the closing component P cos α diminishes and the opening component P sin α increases. The wound will thus tend to gape more and more readily as K advances towards B. When K coincides with B we have the incision LB the corneo-scleral flap incision. α is now the angle LBO. At B we reach a critical point. Here the corneal and scleral curvatures meet. In the case of the cornea the pressure is acting along OB whilst in the case of the sclera it is acting along VB which has the effect of increasing the angle α enormously. The angle LBV, which is α for the case of the scleral curvature, is nearly twice as big as the angle LBO, which is the angle α for the corneal curvature.

The sines and cosines of these angles are easily calculated:—

$$\text{Sin LBO} = \frac{\text{OD}}{\text{OB}} \qquad \text{Sin LBV} = \frac{\text{DV}}{\text{VB}} \qquad \text{Cos LBO} = \frac{\text{DB}}{\text{OB}}$$

$$\text{Cos LBV} = \frac{\text{DB}}{\text{VB}}.$$

By the Pythagorean theorem $\text{OB}^2 = \text{OD}^2 + \text{DB}^2$, hence $(7)^2 = \text{OD}^2 + (5{\cdot}5)^2$ and $\text{OD} = \sqrt{49 - 30{\cdot}25} = \sqrt{18{\cdot}75} = 4{\cdot}3$. Similarly VD = 10·7 nearly.

Applying these values we have :—

$$\text{Sin LBO} = \frac{4{\cdot}3}{7{\cdot}5} = 57. \quad \text{Sin LBV} = \frac{10{\cdot}7}{12} = {\cdot}89. \quad \text{Cos LBO} = \frac{5{\cdot}5}{7} = {\cdot}79. \quad \text{Cos LBV} = \frac{5{\cdot}5}{12} = {\cdot}46.$$

We can now compare the numerical values, for a given pressure P, of the opening and closing components of the incision LB regarding it in the one case as a corneal incision and in the other as a scleral.

	Corneal Incision.	Scleral Incision.
Opening Component =	P sin LBO = P $\times$ ·57	P sin LBV = P $\times$ ·89.
Closing Component =	P cos LBO = P $\times$ ·79	P cos LBV = P $\times$ ·46.

We thus see that, if we compare incisions taken in the same direction and otherwise the same except that the one is in the corneal and the other in scleral part of the corneo-scleral region, the magnitude of the force at the wound margin causing gaping in the case of the scleral incision is to the magnitude of the force causing gaping at the wound margin in the case of the corneal incision as ·89 is to ·57, or more than one and a half times greater ; whilst the force tending to keep the wound closed, the closing component is just about twice as great in the corneal case as it is in the scleral. We thus have a multiplied effect, the liability of the scleral wound to be opened by the forces acting on its margin is roughly 3/2 $\times$ 2 or three times greater than that of the corneal ; and it is all due to the difference of angle which the plane of the incision makes with the radii of curvature in the two cases respectively.

This I regard as important especially in its application to operations for the relief of glaucoma, and in its relation to the production of astigmatism in operations for cataract. We arrive at an explanation of the gaping wound and "filtering cicatrix" obtained in some cases of flap incisions taken in the sclera. It affords an explanation of how iridectomy for glaucoma acts.

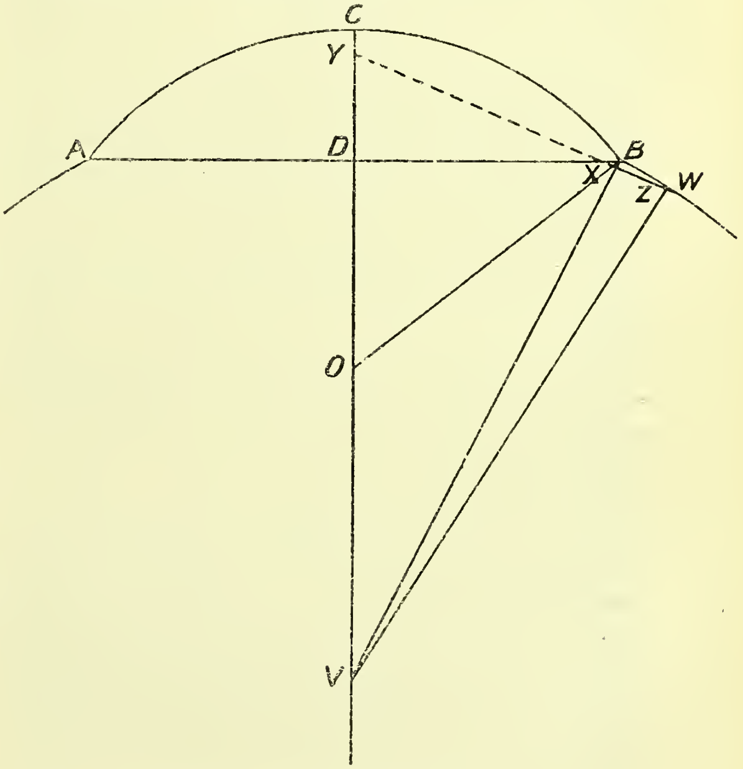


Fig. 3.—*The same as Fig. 2.*

W is the point of entrance of a knife into the anterior chamber through the sclera one millimetre from the corneo-scleral junction B.

WV the direction of a radial wound of entrance WZ.

WXY " " " " WX making an angle of 70° with the radius WV of the sclera.

The successful operation is explained as follows :—The operator in order to get a broad iridectomy well back to the root of the iris has inserted the keratome well back in the sclera at a point such as that represented by W (Fig. 3) and has made a broad wound. To do this without injuring the iris or lens which are bulging forwards and making the anterior chamber shallow the

operator is obliged to turn the point of his keratome forwards so that its plane lies in some direction such as that represented by WY (Fig. 3) producing a scleral flap, WX having a wide alpha angle, the angle YWV. The cosine of so large an angle will be a very small fraction, so that P cos α the closing component will be very small, whilst P sin α the opening component will be large. There will be hardly any tension to pull the flap XW down into place, whilst nearly all the pressure P radiating from V as centre will be acting at right angles to the plane of the incision, thrusting the lips of the wound apart. The opening component in this case is P $\times$ sin angle YWV.

The angle YWV (shown in Figure 3) which is drawn to scale is one of 70°. Now sin 70° = ·94 nearly, so that the opening component in the case illustrated, that of a good incision, is ·94 $\times$ P, which, as I said before, is nearly the whole of the pressure. The closing component P cos 70° = ·34 P, which is small. Compare the values given previously for angles LBO and LBV. The wound will be a particularly gaping one with very little tendency to close. It is likely to produce a more or less permeable cicatrix which will keep the eye soft.

Except that the iridectomy prevents prolapse and incarceration of the iris, I do not see why it should be a factor in the result.

The further back the knife is entered the larger in proportion will be the angle α and hence the less will be the closing component and the larger the opening component.

The fact that the best incision is a scleral one is due to the scleral angle α being almost twice as big as the corresponding corneal one, and the opening and closing components are thereby largely affected as shown in the numerical example.

The fact that an operation sometimes does not relieve the tension and so fails in its object is explained thus :—The operator has made a linear incision, probably with a Græfe's knife, in the plane VW. I have indicated such an incision by WZ (Fig. 3). The incision is in the plane of a great circle, the angle α is the angle ZWV = 0° whose cosine is unity and whose sine is zero, so that there is no opening component. The incision, therefore, for the reasons already stated when discussing the incision LQ, will remain closed, and will prevent fluid from escaping even when under pressure, so that the tension of the eye will not be relieved.

The explanation of the fact that an operation sometimes relieves for a time but that the glaucoma subsequently recurs is that the incision has been made intermediate in character between the bad linear incision WZ and the good scleral incision with flap WX, the α angle being between 0° and 70°. Intermediate angles may allow the wound to pass fluid for a time, but eventually it closes impermeably, when, should the factors which cause glaucoma be present, the high tension can return.

In this connection one may read with interest the observations of Colonel Herbert, I. M. S., in his careful work on Cataract Extraction, edition of 1908. On page 71, when describing the making of his incision, he says : "During the sawing movements attention is directed to the outlining of the conjunctival flap at either side, and this determines any slight forward or *backward* twist of the knife which may be necessary." On page 79 he says: "We have to operate upon many eyes in which the provision of a conjunctival covering complete from end to end of the incision is specially indicated." Further on he remarks upon the incision necessary for this (page 80): "The drawback to a large conjunctival flap is the *separation of the wound which takes place afterwards.*" On page 81 : "The making good of any deficiency of the conjunctival flap necessitates turning the edge of the knife a little *backwards in completing the sclero-corneal section.*"

These quotations show that this surgeon frequently makes incisions which must enter the sclera and especially so at the apex of his incision where he may turn the edge of his knife backwards thus rotating its plane more or less into a plane of direction YW. Now see what he says as to results. Speaking of the healing of his incision with conjunctival flap he writes (pages 152-153) :—"Temporary breaking down of the adhesion, re-emptying the chamber for a few days, *is not very infrequent.* If the conjunctival flap be *fairly long* as well as extensive, the gaping of the central portion of the underlying wound may be considerable, a millimetre or more across. Approximation of the surfaces may never be complete, and the permanent repair of the wound must then depend largely upon the episcleral tissue overlying and occupying the gap. A 'filtering cicatrix' results, allowing aqueous to pass through to the subconjunctival tissue in the neighbourhood, where it keeps up a permanent slight œdema."

Again on page 155 we find :—

"Many of the operations had been performed with unnecessarily large conjunctival flaps. There were, consequently, many cicatrices certainly filtering, and many others doubtful in this respect......... the ocular tension was normal or only slightly sub-normal, but could be *reduced rapidly by pressure upon the eye.*" This condition would be just the thing to aim at getting in a case of glaucoma. Regarding astigmatism he says (page 158) :—

"The absence of any notable tendency to diminution of the astigmatism must be counted a definite drawback to the use of a large conjunctival flap." He mentions that astigmatism has reached as high as 7 Dioptres.

I have quoted thus largely from Colonel Herbert's admirable notes and remarks because they are evidently those of a painstaking, candid and accurate clinical observer and may be relied upon, and because they appear to me to afford the clinical proof of my *a priori* theoretical deductions. The italics in the quotations are mine.

Gaping wounds evidently go with large conjunctival flaps, leading to soft and astigmatic eyes. Colonel Herbert's explanation, I think, is wrong. The explanation is that to get a large conjunctival flap, and especially a *long* conjunctival flap, the incision has to be made *scleral* and gets the effect of the large scleral alpha angle LBV instead of the corneal alpha angle LBO of about half the

size. Further, if the blade of the knife be directed *backwards* before cutting out, it means that the plane of the incision is not that of LB but of some direction such as XW (Fig. 3), which has the effect of still farther increasing the size of the alpha angle at the apex of the incision, making it very suitable for a case of cataract with glaucoma.

With regard to astigmatism it would seem as if the size of the area of the flap which is left with its normal lines of resistance weakened by the incision has a bearing on its production in addition to the factors already considered. If this is the case we see by a reference to Figure (2) that for a given site of puncture and counter-puncture such as L the size of the area of the flap LKQ, that is the surface between the planes LK and LQ, will depend upon the length of the arc QK, the longer we make the arc QK the larger will be the area LQK; the shorter the arc, that is the nearer the incision approaches to the radial one LQ, the less will be the amount of area deprived of its normal support, till when the incision is actually radial there is no area without its natural support. The more the incision diverges from a radial one the greater will be the area liable to astigmatism.

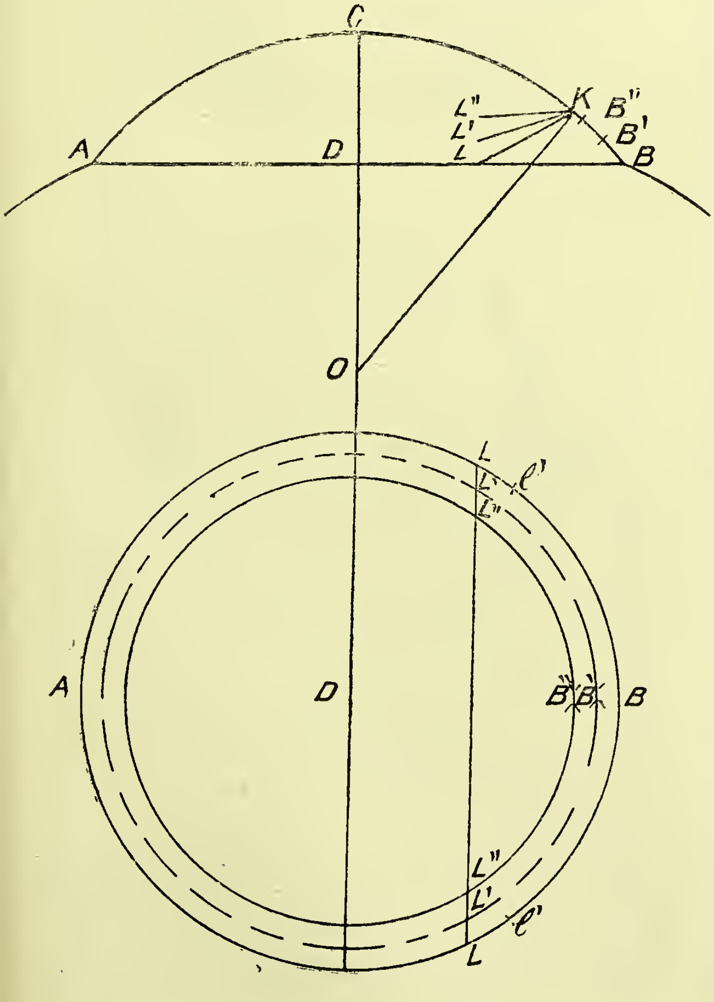


FIG. 4.—*The same as* FIGS. 2 *and* 3.

The lower drawing is the projection in plan of the upper one.

UPPER DRAWING.

L is puncture and counter-puncture in corneo-scleral margin.
L' is same in cornea 5 mm. in front of corneo-scleral margin.
L'' is same but 1 mm. in front.
B, B', B'' are the projections of L, L', & L'' on to the corneal surface BCA which give the radii DB, DB', & DB'' (below) for the circles in plan.

LOWER DRAWING. THE PLAN OF ABOVE.

LL the points of puncture and counter-puncture in the corneo-scleral margin on a line 2·5 mm. distant from and parallel to the horizontal meridian passing through D, which is the centre of the corneal base.
L' L' are similar points 0·5 mm. more anterior.
L'' L'' are similar points 1·0 mm. more anterior.
B, B', B'' the projections of B, B', B'' (above).
ALBL the internal corneo-scleral margin circle.
L' B' L' and L'' B'' L'' corresponding circles in parallel planes 0·5 and 1·0 mm. anterior to circle ALBL respectively.
l' l' are points on circle A L B L giving a chord l' l' of same length as chord L' L' on circle L' B' L'.

A B = 11 mm.	L L = 9·8 mm. approximately.
O K = 7 mm.	L' L' = 8·8 mm. „
D L = 2·5 mm.	L'' L'' = 7·1 mm. „

In Fig. 4 the upper drawing represents the same section of the corneal region as do Figs. 1, 2, and 3. The lower drawing is the projection, in plan, of the points shown in the upper drawing. It is very easy by running the eye along the lines of the squared paper to pick up the corresponding points in the plan and elevation of the cornea, and to measure the distances between any points in plan or elevation by counting the intervening squares. Above in Fig. 4 the point L marks the site of puncture and counter-puncture, and below the two points are shown in plan, the distance between them L L being 9·8 millimetres as can be confirmed by counting the lines or by calculation. Call the distance between L and L $2l$. The distance of LL from the horizontal meridian is here taken at 2·5 mm. The formula $R^2 = \sqrt{DL^2 + l^2}$ where R is the corneal radius, here 5·5 mm., will give any measurement when the other is given. But for practical purposes the best way is to look at the diagram to get the measurements. Fuchs gives the diameter of the lens as 9 mm. and its thickness as 5 mm. Thus if we wish the incision to be 9 mm. wide we look at the diagram and we see that LL must be 3·2 mm. from D and 2·3 mm. from B. In the diagrams 1, 2, 3 and 4 LL is 2·5 mm. from D, giving the width of LL = 9·8 mm. If we wish LL to be 10 mm. the diagram Fig. 4 shows that we must make the puncture and counter-puncture 2·3 mm. from the horizontal meridian.

Whilst the full diameter of the lens can thus be provided for, it is otherwise with its thickness. If L is 3 mm. from B, as in the diagrams, and the cut be made along LB, the utmost the flap LB can roll back is to the position LQ; and in practice it could not easily do so without contracting the diameter $2l$. If the flap were to fold back so far the gap would only be as big as LB or BQ, not more than about 3 mm. in extent, whereas the thickness of the lens is 5 mm. Even were the incision begun at D and the whole of DB turned back, there would only just be room for the thickness of the lens to pass without distortion. It is thus seen that any practical incision entails that the lens

should be squeezed or moulded through the opening made by the incision, that is, if the lens is to be removed entire. And I may here remark that after an experience of over 500 extractions of the lens in the capsule, there is no doubt left in my mind that the best way in which to extract the vast majority of lenses is in their capsules. But whichever method we adopt this moulding of the lens will be noticed. And the lesson to be learned is that the harder and less squeezable the lens, or the bigger the nucleus, the wider should be the provision for its exit. Mere size of the lens does not matter much. Clinically I have often seen big fat soft lenses squeeze through openings much smaller than themselves. On the other hand small atrophic lenses consisting chiefly of a large and comparatively rigid nucleus are often very difficult to extract even through a large incision.

Reverting to Fig. 4, as LL is 9·8 mm. it may be regarded as just sufficient to allow the 9 millimetres of the lens to pass because, when the lens presents, the lips of the wound are thrust apart and put upon the stretch and the points of puncture and counter-puncture are thereby approximated. Now look at the puncture marked L′. This point like L, is 2·5 mm. from the horizontal meridian, but it is ·5 mm. anterior to the corneo-scleral margin. In the upper figure run the eye along horizontally and we find the point B′ where the horizontal projection of the point L′ meets the corneal arc ACB. This gives the radius DB′ of the dotted circle in the plan. The distance between puncture and counter-puncture is now shown by L′ L′ on the plan and is equal to 8·8 mm. This is now less than the diameter of the lens; and one millimetre has been lost in the width of the incision by making the puncture half a millimetre more anteriorly. A similar width would be given by a puncture in the corneo-scleral margin at a point about 3·3mm. from the horizontal meridian as is shown by the projection *l′ l′* of the points L′ L′ on to the corneo-scleral circle LBL in the plan.

If we look at the puncture L″, which in the upper figure is one millimetre from AB, its projection and that of its counter-puncture are at L″ L″ on the circle L″ B″ L″ of the plan, and the distance L″ L″ is seen to be 7·7mm., which is 2·1mm. less in width than the corresponding corneo-scleral puncture. Projecting L″ on to the corneo-scleral circle we see that this width would be got by a corneo-scleral puncture nearly 4mm. from the horizontal meridian.

The diagrams therefore show very well the great loss in room entailed by making puncture and counter-puncture in front of the corneo-scleral margin, and indicate that if it is desired to get a roomy incision the knife must be entered as far back as possible.

But this is not all. The upper diagram clearly shows that, when making a flap incision LK, the alpha angle LKO is the more increased the more anteriorly we make the puncture and counter-puncture. Thus angle L″ KO is greater than angle L′ KO which itself is greater than angle LKO. In fact angle L″ KO is nearly double angle LKO, so that the incision L″ K is a much more flap like incision than is LK.

To sum up: an anterior position of the puncture and counter-puncture makes a wound narrower in width and more flap like and gaping than does a more posterior position when we take the same distances from the horizontal meridian of the cornea for the beginning and the end of the incision in each case.

Anatomical and Physiological.

For purposes of description I will call the apex of the cornea the anterior pole of the eye, whilst the macula would be the posterior pole. Great circles passing through these poles will be called meridians, whilst circles parallel to the equator will be called equatorials. The anterior chamber becomes rapidly shallower as its periphery is approached where the anterior plane of the iris meets the sclerotic forming the angle of the anterior chamber. Incisions opening the anterior chamber in the neighbourhood of this angle are therefore more likely to damage iris, ciliary body, suspensory ligament of the lens or lens-capsule than when placed more anteriorly. On account of this proximity also, it is easier for iris or pieces of lens capsule to become included in wounds in this region.

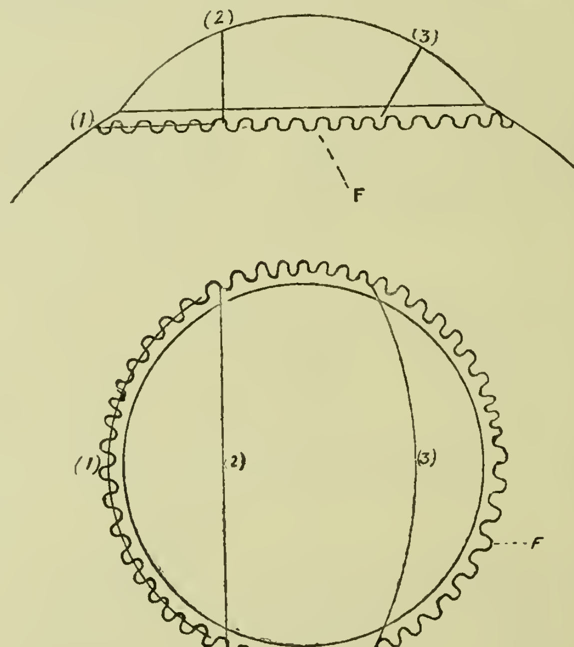


Fig. 5.—*Elevation and Plan of Cornea and adjacent Fringe of vessels.*

F the fringe of vessels.
(1) A corneo-scleral incision dividing vessels.
(2) Meridional ,, ,, few. ,,
(3) Radial ,, ,, ,, ,,

The posterior part of the corneo-scleral zone is the site of the fringe of capillary loops which terminate the meridionally placed ciliary arterioles. An equatorially placed incision—Fig. 5 (1) in this situation will cut the greatest number of loops, whilst a meridionally placed incision—Fig. 5 (2) will cut the fewest. *Pari passu* with inclusion of the conjunctiva scleræ in the incision additional

vessels are cut, and these are of a larger calibre. The nearer the clear cornea is approached the smaller and finer are the vascular loops.

Other things being equal then, bleeding will be greater the more scleral and the more equatorial the incision, whilst bleeding will be less the more corneal and the more meridional the incision. The more the scleral conjunctiva is cut the greater the bleeding.

The transparent cornea is nourished by lymph transuded from the capillary circum-corneal fringe. This lymph permeates the cornea by its lymph channels, and the fibres lie in lymph and are nourished by it in just the same way as fibrous tissue is in other parts of the body.

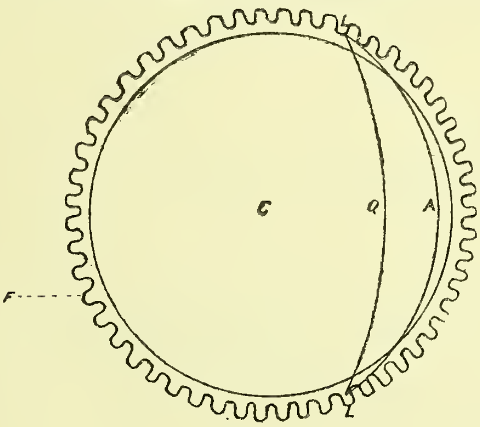


Fig. 6.

C the centre of cornea.
Q „ apex of a radial incision LQL.
A „ „ „ flap „ LAL.
F vascular fringe.

The diagram Fig. 6 represents the cornea surrounded by its capillary fringe. In the intact cornea the centre C is the part farthest from the source of lymph. But if an incision such as LAL be made, or like (1) Fig. 5, the part at A will be farthest from the supply of lymph. Its usual supply from the adjacent capillary loops has been cut off by the incision, which not only directly severs the lymph channels but also leads to their occlusion by the swelling of the cut corneal fibres which is produced by contact with the aqueous humour. The corneal fibres are normally bathed by the lymph with which they are isotonic. When brought in contact with the aqueous, which has a lower specific gravity than the lymph, osmosis takes place, they imbibe fluid and so become swollen. The fibres cannot swell without blocking the lymph channels, and so the lymph is prevented from being absorbed, or from oozing out at the cut edges. And here I would like to make a parenthetical hypothesis. It is that the haziness and fog and striæ of the cornea which sometimes occur after operations is caused as follows: the anterior chamber is opened; the aqueous is in contact with the cut edges of the cornea; stroking or other movements are made in such a manner as to drive and squeeze the lymph in the cornea towards the wound where it escapes at the cut edge. The milking movements being suspended aqueous becomes sucked by capillary attraction into the emptied corneal lymph channels; it gains entrance at the cut margin of the cornea where the lymph got exit: not being isotonic with the corneal fibres it causes them to swell and alters their homogeneity with respect to light so that diffraction is caused and a consequent loss of transparency.

To return to the incision LAL. The sources of lymph nearest to A are now at L and L. Let LQL (Fig. 6) represent the arc of a great circle between L and L. Then the arc LKL is the shortest distance on the spherical surface between the points L and L; and hence for a puncture and counter-puncture at L and L the incision LKL, that is a radial one, has the margins of its wound the nearest possible to the nutrient blood-supply. Incisions on either side of this, towards C or A will have one margin of the wound farther from the blood-supply than the radial incision LKL, and the distance for one margin will be the greater in proportion to the amount of the deviation from the radial position.

The Circulus Iridis Major lies posterior to the corneo-scleral margin and to the angle of the anterior chamber. A Graefe knife entering the anterior chamber in the region of its angle and in a plane anterior to that of the iris will avoid wounding this arterial circle, whilst if entering as posteriorly as the plane of the iris it will almost certainly cut this circle,—an accident which causes considerable bleeding. A radial incision, therefore, begun anteriorly to the plane of the iris will cut a few vessels of the capillary order, if any, and will leave the margins of the wound the least disturbed as regards nourishment.

Pathological.

The swelling of the corneal fibres and the arrest of the lymph stream after incision of the cornea have been already alluded to. When this occurs in a radial incision, it will cause a rapid sealing of the wound which will not readily open again. The lips of the wound become gummed and jammed together in their natural position without deformity of the corneal surfaces as a whole. The surface epithelium will grow down into the crack left by the retraction of Bowman's membrane and will then join with its fellow of the opposite side. The depression then becomes elevated by growth of tissue from below till a smooth and even surface is produced; and but for the thin line of opacity and the gaps in the elastic membranes there is a complete *restitutio ad integrum* of the cornea, which becomes as strong as it was before. The case is different when the wound gapes: not only is the cicatrix broader, but the epithelium gets time to grow down farther on the cut edges of the wound so as to cover the deeper layers of fibres, so that the whole thickness of the cornea cannot unite at the same time, as it will do if the wound does not gape and its edges are opposite to one another. A flap-like wound, which is also the kind which tends to gape as shown in the mechanical section, has the farther disadvantage of the over-riding by the flap before alluded to. Hence correspouding surfaces are not united together: the deeper part of the edge of the flap tends to unite

with the more superficial part of the opposite margin of the wound. There is consequently a prolonged weakness of the cicatrix which may, indeed, be permanent in bad cases: astigmatism is also produced as a consequence.

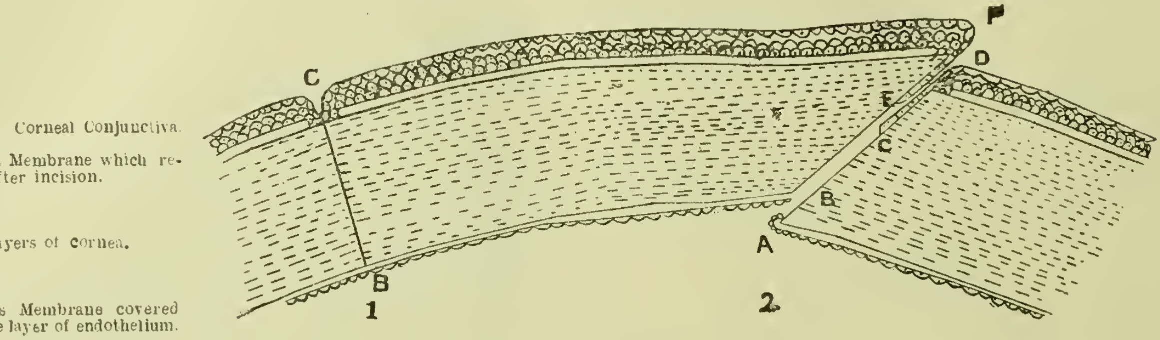


FIG. 7 (*Diagramatic.*)

(1) is the healing of a radial incision.
(2) ,, ,, ,, flap ,, which has gaped and is over-riding.
BC parts which are uniting. Notice the length and linear character of (1), the shortness and width of (2).
AB and DF parts which have nothing to unite with.
CD part covered with epithelium, preventing union.
EF ,, ,, ,, ,, ,, ,,

The diagram Fig. 7 is designed to bring out these points. Case (1) is a healing radial incision. Case (2) is a healing flap incision which has gaped and which is over-riding. The part BC marks where union has taken place. Contrast (1) and (2). In (1) we have direct union of the whole thickness of the fibrous layers of the cornea and no distortion. In (2) there is union over a limited area. The part AB has nothing to unite with. The part CD becomes covered with epithelium during the gaping of the wound and the part EF becomes covered with epithelium and has nothing to unite with. A wound such as (2) will take longer to heal and will be more delicate and liable to burst open than a wound such as (1). It will evidently also cause astigmatism.

Another disadvantage of a wound healing as does (2) is that it is more liable to microbic infection. It presents an elevation above the surface of the cornea and a deep groove beneath it which permits of foreign material obtaining a lodgment and shelter from the cleaning action of the eyelids and tears. Moreover, the upper part EF until covered by growth of epithelium is an open raw wound.

The question of infection of the operation wound is of great importance. It is so important that having determined to incise the eye, the liability to infection is the first thing to be considered when deciding upon the choice of method. The fear of infection has led many, perhaps the majority of surgeons, to abandon for the purpose of cataract extraction corneal incisions which are uncovered by conjunctiva. They base their practice on imitation of others and on the experience which was gained in the pre-antiseptic era. This experience is reported to have been that suppuration of the wound occurred more frequently when the incision was corneal than when it was underneath the conjunctiva. But on the other hand it is also reported that there were more cases of irido-cyclitis by the latter method. It is thought that the conjunctiva by covering the wound will save it from infection; and also it is thought that a peripheral position of the wound gives it the protection of the very adjacent blood-supply, whilst central incisions are farther removed from the bactericidal blood-stream. The question is to be settled by experience but there are also some arguments which it may be worth while to advance in dispute of the above contentions.

As regards experience: my own extends to about 500 cataract extractions without a conjunctival flap. I had two cases of suppuration. Both were in the same patient, operated on at the same sitting, and were probably due to an error in technique. It was one of my first twenty cases and my lack of skill probably caused me to infect an instrument on an eyelid or some other part of the patient.

As regards theoretical considerations; the fear of infection based upon the results reported before the era of Pasteur is somewhat of the nature of a bogey in these days, especially when one knows that in those days no kind of wound was safe from suppuration. The cornea appears to me to heal as quickly and as easily as any other kind of connective tissue. A conjunctival covering of the wound will probably tend to prevent subsequent infection of the wound; but not more so, it seems to me, than the agglutination of the swollen fibres of the cornea itself, such as takes place when one makes a radial incision. But what about infection of the wound occurring at the time of operation? *That*, it appears to me, is the principal danger. Most wounds which go wrong are probably infected at the time of the operation. It is very easy to infect an instrument on an eyelid or other part during an operation. If one watches an unskilled operator one sees him doing it. It requires but the merest touch, the brushing of an eyelash, to convey germs on to the instrument and hence into the wound, the raw surface of which may be well rubbed by the instrument. Covering up such a wound with a conjunctival flap will conceal it; it will not prevent or remove the

infection, which, if virulent enough, will cause suppuration despite the covering. True the covering may conceal the suppuration and the case may be called irido-cyclitis as it was in the old days. But the result is the same to the unfortunate eye. Indeed the covering might be harmful, by directing the infective process inwards instead of letting it get out. Again the surface of the cornea is more efficiently cleaned by tears than is the scleral conjunctiva, so that germs are more likely to be adherent to the scleral than to the corneal conjunctival surface: thus the very cutting of the scleral conjunctiva may infect the knife more readily than cutting the corneal conjunctiva, which infection might be carried to the deeper parts of the wound. That suppuration does not oftener occur is probably due to the deep parts being able to dispose of germs so long as they are not too virulent in quality nor too large in quantity.

The deep layers of the cornea possess the requisites for dealing with infection. We know that germs are first of all acted upon by the complement of the blood or lymph and then swallowed by the leucocytes if not dissolved by a lysin. Complement is contained in lymph or blood-serum to the same extent as in blood-plasma. All the fibres of the cornea are bathed in complement-bearing lymph: the lymph also contains leucocytes: and when required these increase in number. A reflex stimulus opens the sluice-gates of the circumcorneal arterioles, and lymph and leucocytes in quantity are available at the site of injury.

The point as to the distance of the site of injury from vascular loops has been dealt with in the section on anatomy and physiology; and the proposition that a peripheral wound is nearer the blood-supply is shown to be not true in the case of flap-like wounds. In these one margin is farther away than it would be if the wound were not so peripheral.

In my opinion the surgeon who operates skilfully on an eye with healthy appendages, and who does not infect his instruments during the course of the operation, nor allow his own or his assistant's saliva to be projected on to the eye, has little to fear from suppuration of his incision wherever placed; and he may incise the cornea covered by corneal conjunctiva with as much confidence as that covered by the scleral conjunctiva.

The pathology of inclusion of iris, capsule, lens matter and vitreous in the wound has been so often dealt with that I have nothing original to note about it. Every one will admit that if by a certain planning of the incision these accidents can be minimised it is desirable to so plan the incision, provided always we can do so without neglecting other equally important considerations.

Technical.

A few points deserve consideration under this heading though it is not intended to discuss the whole of the technique of incisions of the eye. The theory of the preceding sections shows that the best incision for the extraction of cataract will as a rule be a radial corneal one. Indeed the arguments so far brought forward are so overwhelmingly in favour of it that it immediately occurs to one to surmise that there must be some grave practical objection to its use, or otherwise it ought to have been generally adopted long ago. The possible objections, so far as I can think of, are three:—

(1) Interference of the scar with vision.
(2) Difficulty or impossibility of extraction through the incision.
(3) Difficulty of making the incision.

I suspect that one or more of these, or a combination of them, has stood in the way of the incision. I will examine them seriatim.

(1) *Interference of the Scar with Vision.*

This is a question upon which the future of the incision will be decided: not on account of astigmatism due to proximity to the pupil as many have thought, because I have shown that a radial incision does not produce astigmatism; but because of the opacity due to the scar in the neighbourhood of the pupil.

If one refers to Fig. 2 it is manifest that the radial incision LQ will give a clear cornea in front of a pupil 7 millimetres in diameter QQ′. It is only exceptionally that the pupil is dilated to this extent. But the scar will have a certain width along meridional arcs, so that there will be a slight encroachment on this account. But it will be only slight if the incision is cleanly and properly made. If we imagine the scar to be 2mm. wide we would be imagining a very wide scar for a radial incision. With the close approximation of the wound margins obtained in a cleanly cut radial incision such a width is not to be expected. But supposing such a width it would only mean an encroachment of 1 mm. on the pupillary side of the scar, thus reducing the possible diameter of the pupil with clear cornea in front of it to 6 mm. But 6 millimetres is ample for ordinary dilatations of the pupil.

As a matter of fact a scar due to an incision such as LQ (Fig. 2) is practically wholly covered by the upper eyelid, and is not visible from a cosmetic point of view; and the cornea in which it lies does not as a rule give passage to rays of light which are used in vision. But for these favourable conditions to be obtained it is essential that the pupil should remain central. If the iris prolapses into the wound, or if the vitreous prolapses and becomes adherent to the wound, there will be more or less drawing up of the pupil. One often sees cases where even the usual very flap-like peripheral incisions have not been far enough removed from the pupil to prevent its being drawn up right under the apex of the scar at the periphery of the cornea. In these cases the pupil follows after the incision as if guided by some malign demon. The truth is that no incision can escape this danger if either iris or vitreous be included in the scar: and the only advantage which the peripheral incision has is that if the prolapse be but slight and the effect on the pupil but slight, it will not be drawn up far enough to be interfered with by the scar. But it will be interfered with by the upper eyelid, which comes to much the same thing. And the peripheral incision has this disadvantage, that the more peripheral it is the farther is the pupil

likely to be drawn up in any given case, leading to more fixation and stretching of the iris and a more unfavourable condition in the event of an optical iridectomy having to be performed subsequently. Whereas a radial incision like LQ has this great advantage over all others that both owing to its position and to its direction the chances of iris or vitreous healing in the wound are reduced to an absolute minimum.

I did not become fully alive to the advantages of a radial incision till I had written the previous sections, and although I have practised it since, I have not done it in a sufficient number of cases to justify the publication of results. This I hope to do at some later date. But I may say that so far it has fully justified my expectations.

(2) *Difficulty or Impossibility of Extraction through the Incision.*

The incision LQ shown in Fig. 2 gives a width for exit of the lens of 9·8 millimetres; and in practice I have found this to be sufficient to allow of the lens being delivered entire in its capsule. I have designed the incision in order to admit of this, which is the ideal operation for most cataracts. Extraction in the capsule requires more room for the exit of the lens than any other operation. In the cases in which I have done extraction in the capsule through a radial incision I have extracted the lens without undue difficulty and without any complications. But there is only just room. The incision must be placed as LQ and have the puncture and counter-puncture well back in the angle of the anterior chamber so as to get sufficient width (see Fig. 8). Then by suitable manipulations the spherical form of the eye is destroyed which permits the wound to gape sufficiently to give exit to the entire lens in its capsule. (It is obvious that so long as the eye retains its spherical form the radial wound cannot open at all.) When the manipulations are over and the lens out the spherical form becomes quickly re-established and the wound is closed of necessity, rendering that bugbear of the operator, subsequent prolapse of iris or vitreous, a thing of difficult occurrence.

Those operators who extract with capsulotomy need not adopt quite so large an incision. They must judge each case on its merits, remembering that the larger and harder the nucleus of the lens the wider must be the base of the incision. The smaller the nucleus of the lens the nearer to the point B (Fig. 2) the puncture and counter-puncture may be made. So long as sufficient room is obtained for the passage of the nucleus, the nearer the incision can be brought to the upper margin of the cornea the easier it will be to express the debris of the upper segment of the lens. With an incision such as LQ (Fig. 2) it will be difficult to express the debris from beneath the segment of cornea LBQ. There will be a tendency for fragments of lens matter to accumulate in this region, and downward pressure and stroking will be required to express it. A radial incision such as Von Graefe's one or one intermediate between Von Graefe's and the radial incision LQ of Fig. 2 according to the size of the nucleus seems to me to be best adapted to the requirements of these who extract with capsulotomy.

The real cause of the abandonment of Von Graefe's incision was probably because operators did not obtain enough room. It is very easy to make the mistake of entering the knife, not in the angle of the anterior chamber as it should be in order to get the full width of incision as shown by the plan in Fig. 4, but anterior to this. The nearer we approach the upper limit of the cornea (B) the greater will be the effect of an anterior position of the puncture and counter-puncture in diminishing the width of the incision. Unless this fact be carefully borne in mind the operator is almost sure to make his incision too small, so deceptive is the appearance of the relations of parts near the limbus of the cornea. The puncture should be begun well over the sclera so as to enter the anterior chamber at its angle; and Von Graefe's description of how he made the incision by pointing the knife towards the centre of the pupil seems to me to have been unfortunate as it tends to induce operators to make the puncture too anteriorly. It is, I think, because Graefe's incision was wrongly made that it has fallen into disrepute; and I am inclined to think that those surgeons who practice the capsulotomy operation should revert to Graefe's radial incision for lenses with small nucleus and make radial incisions placed between that of Graefe and my own for hard lenses with larger nuclei.

(3) *Difficulty of Making the Incision.*

Here again this incision has an advantage over others. Properly executed it is easier to make than the corneo-scleral flap, and especially in those cases in which the corneo-scleral incision is difficult; and this brings me to the points in technique proper to which I wish to allude: *Execution of the radial incision LQ (Fig. 2) for the extraction of cataract in the capsule.*

The conjunctiva is grasped in the vertical meridian immediately below the cornea. It is important that the grip should be exactly opposite to the intended apex of the incision; that is that the points of the fixation forceps and the apex of the incision should be on the same meridian.

The eye is pulled well down, but *no pressure* is put upon it by the forceps. This is exceedingly important, as pressure may baffle the operator by causing the iris to bulge forward and entangle his knife: or he may even injure or dislocate the lens and so bungle his operation at the outset. An ivory-handled Graefe knife (I hate metal ones and can't imagine why they are made, because he who boils his knife blunts it. Are we to be dominated by the shibboleth "Aseptic Metal Handles"?) is delicately grasped, not near the shoulder as is commonly taught, but well away from it so as not to cramp the fingers as they thrust the knife through the eye. The knife is held very lightly by the fingers and thumb which should alone give it its motion. The hand is conveniently supported on the patient's head. The plane of the blade should be in the plane of LQ.

A reference to Fig. (2) will show that $OQ = OQ' = QQ' = 7$ millimetres : so that OQQ' is an equilateral triangle; and angle $Q'QO$ is 60° and as QQ' is parallel to AB the angle QLB is 60° or 2/3 of a right angle. Hence the knife should be entered with the plane of its blade at an angle of 60° to the plane of the corneo-scleral margin. This angle being two-thirds of a right angle makes it very easy to judge which is a convenience. The long axis of the knife should be in the line of puncture and counter-puncture ; it is not advisable to direct the knife more vertically to the surface at the place of puncture, because the puncture being intended to introduce the knife into the anterior chamber at its very angle there is no margin of safety for the iris, which would become at once engaged by the point of the knife when it penetrated the anterior chamber if the knife were directed towards the centre of the eye.

The introduction of the knife with its blade in the 60° plane has some advantages which cause the incision to be much easier of execution and less liable to undesirable complications than is the case when the blade is introduced in the corneo-scleral plane as commonly practised.

The knife enters more easily in this plane than in the equatorial. It was first pointed out to me by Major Smith of Jullundur that the knife would enter more easily if slightly rotated out of the equatorial plane. He has had great experience with blunt knives, and it is when the knife is not quite up to the mark that the shade of difference becomes apparent. It will be found that the same pressure which fails to cause penetration when the blade is equatorial will cause penetration when the blade is slightly rotated out of the equatorial plane. At least that is my impression. I surmise that it must be due to the architecture of the corneal layers. One can imagine that when the blade is in the equatorial plane it wedges its way between parallel equatorial layers of fibres, and acting more like a wedge than a knife it meets with more resistance than it does when the edge of the blade is turned a little forward so as to sever these fibres instead of wedging them apart.

Another advantage of the 60° plane is that the knife is more easily guided into the anterior chamber at the correct spot when held in this plane. It enters at once in the desired direction. Whereas when held in the corneo-scleral plane there is a tendency to split the layers of the cornea so that penetration occurs much nearer the vertical meridian than was intended. This means too small an exit for the lens and a bungled operation. It can be avoided, of course, by skill. But it adds one more difficulty to the operation, and a serious one to the unskilled. Likewise it is easier to make the desired counter-puncture when the knife is in the 60° plane. When held equatorially the unskilled operator often cannot make the knife come out at the proper place, especially if the knife be rather thin in the blade as it tends to burrow between the layers of the sclera. The certainty with which a correct puncture and counter-puncture can be made when the blade is held in the plane LQ will appeal to all beginners.

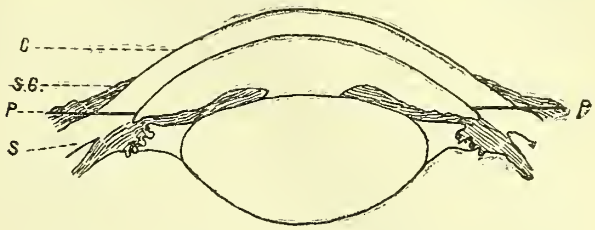


FIG. 8.—(*After Meller*).

C: is cornea. S: sclera.
S.C: scleral conjunctiva.
P.P: line of puncture and counter-puncture.
Note the position well back at the margin of the anterior chamber.

The knife, then, being held in the correct plane and axis, is introduced well back in the sclera so that the point will enter the anterior chamber just in front of the root of the iris (see Fig. 8). The points of entrance and exit will be in a line two and a half millimetres distant from and parallel to the horizontal meridian.

Having got the knife into the anterior chamber it has now to be pushed across to the counter-puncture. The back of it is almost in contact with the iris. If the anterior chamber be deep and the iris flat, all that is necessary is to push the knife straight across. But often the iris will be bulging forward, lying on a swollen lens. The axis of the knife must then be altered and the point directed slightly forward towards the posterior surface of the cornea. When the point has passed the vertical meridian, the opposite motion is given to the axis of the knife and the point sinks again towards the site of counter-puncture. The back of the blade may now press upon the iris and thrust it and the lens a little back, but no harm whatever ensues, as the iris does not become entangled. The counter-puncture is made deep in the angle of the anterior chamber, and then the knife continues onwards. But immediately the point has pierced the sclera pressure is applied so that the edge cuts out in the plane of the knife, that is of LQ. If the knife be sharp and the operator skilful it is easy to complete the incision before the heel of the blade reaches the puncture. The result is the cleanest possibly cut incision ; an incision hardly visible and giving beautiful coaptation of the margins of the wound. But if the incision is not completed during the forward thrust it is completed on the backward one, and if the reversal of the motion be done properly, the incision will be practically as clean cut as in the first case. Sawing movements are unnecessary and should not be indulged in. They leave an irregular and ragged wound which does not heal as well as the clean-cut wound. And in this situation, so near the pupil, this is important.

The completion of this incision, after having made the counter-puncture, is easier of execution than in the case of corneo-scleral or other flaps. Besides being shorter and thus easier to do with one thrust of the knife, it has another advantage. In sunken eyes or eyes with a sclerosed and contracted conjunctiva, or where the eye is set very close to the nose, it is difficult to

thrust the knife far towards the hilt on account of its impinging on the eye-lid, caruncle, or nose. This difficulty is much more marked when making the corneo-scleral incision. Certainly there is an art, which may be acquired, which consists in supporting the eye on the flat of the knife and raising it from its socket, at the same time rotating it outwards, whereby the point may be cleared and the corneo-scleral incision completed in the forward and backward thrust. The manipulation, however, is only one for the expert, as four motions are being performed at the same time, all in harmony, *viz.*, the thrusting, the cutting, the lifting out of the socket on the flat of the knife and the outward rotating of the eye, the two former making the incision and the two latter serving to clear the knife. But with the radial incision the direction of the cutting itself is such that the force applied tends to lift the eye forwards out of its socket, and it is easy, by depressing the handle of the knife, to rotate the eye a little outwards and thus give clearance to the point without much danger of disturbing the plane of the incision or of making it irregular.

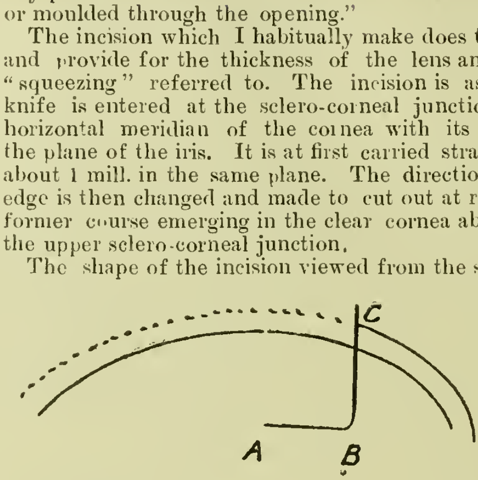
By pulling the eye well down the radial incision may be made by cutting almost directly forwards away from the patient, which makes the thing a very simple matter indeed compared to the execution of a corneo-scleral flap in a deeply sunken eye with a sclerosed conjunctiva. It is an undoubted fact that the easier an operation can be made as regards its execution, the better it will be done, whether by an expert or by a tyro, and the better in general will be the result. The radial incision tends to avoid operative complications; its simplicity is not the least of its merits, and whilst the theory as I have endeavoured to expound it may appear to some people to be complicated, they may rest assured that its practical application is easy; and that the eye and hand can be readily trained to execute what theory demands.

DISCUSSION.

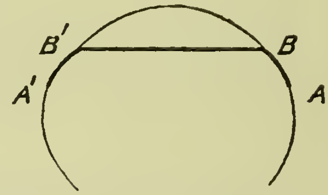
Capt. J. Oxley, I.M.S.:—Capt. McKechnie has remarked: Whilst the full diameter of the lens can thus be provided for, it is otherwise with its thickness" and adds: "It is thus seen that any practical incision entails that the lens should be squeezed or moulded through the opening."

The incision which I habitually make does take into account and provide for the thickness of the lens and minimises the "squeezing" referred to. The incision is as follows: "The knife is entered at the sclero-corneal junction just above the horizontal meridian of the cornea with its blade parallel to the plane of the iris. It is at first carried straight upwards for about 1 mill. in the same plane. The direction of the cutting edge is then changed and made to cut out at right angles to its former course emerging in the clear cornea about 2 mill. below the upper sclero-corneal junction.

The shape of the incision viewed from the side being thus—



and from in front—



By this incision the length A B, (approximately 3 millimetre) or more if desired, is available to allow the thickness of the lens to pass without any approximation of the horizontal incision. This incision, providing as it does for the thickness of the lens, appears to me to admit of puncture and counter-puncture being made at the sclero-corneal junction and not in the sclera. I do not favour a more peripheral incision as being more likely to lead to hæmorrhage and prolapse of the iris.

I adopted this incision because, from its valvular nature, it appeared to me to offer the greatest impediment to prolapse of both the iris and vitreous and moreover to heal without any over-riding of the edges.

As the greatest part of B B′ approximates to the conditions of the "radial incision" the reason for it not gaping has been already demonstrated by the author of the paper.

If the portion B B′ unites correctly without over-riding it must act as a splint compelling the small remaining portion of the incision A B, A′ B′ to unite correctly also.

GLAUCOMA.

By Major P. P. KILKELLY.

In our interest in Cataract extraction there is some danger that sufficient attention be not paid to Glaucoma, a disease which is extremely prevalent in India, and which is responsible for a great deal of the blindness which we see in this country. During the past year I find that 250 cases of Glaucoma were admitted to the C. J. Ophthalmic Hospital; the great majority of these cases was of old-standing Glaucoma. The symptoms had been noticed by the patients months or years previously and it was only when useful vision had been lost, that the patients came to the Hospital for relief.

Various operations have been proposed for the relief of the disease, and successful results have been claimed for operations other than iridectomy: notably Herbert's wedge operation, and Lagrange's. Undoubtedly good results have been obtained by both these operations, but I do not think that it has yet been shown that the progress of the disease is permanently arrested.

I have performed both operations in Bombay, but have invariably lost touch with the patients after a few months, and hence do not feel justified in expressing an opinion as to permanent after-results. I regard these operations full of promise and would bring them to the notice of this section in the hope that some of the members may, at a later date, be in a position to supply us with reliable figures of results obtained.

Personally I regard iridectomy in most old-standing cases of Glaucoma as almost useless, the peripheral incision

and the possible formation of a filtrating cicatrix may keep the tension down for a time, but the iridectomy itself fails.

In acute Glaucoma, however, and such cases of sub-acute Glaucoma as are seen early, a large peripheral iridectomy is of undoubted value. But to be of value the iridectomy must be performed as laid down by Parsons, that is, the incision should be as peripheral as possible, and made, in my opinion, with a Græfe's knife, the iris picked up at one edge of the incision, snipped with the scissors, then torn across the whole breadth of the incision and cut off at the other corner. I may be pardoned for insisting on the details of the method of performing iridectomy, as during the past two years numerous cases of iridectomy for Glaucoma have been under my notice in which the incision was a small corneal one, and merely a small piece of iris had been snipped off as is done in Cataract operation. It is well established that in Glaucoma the periphery of the iris is opposed to the posterior surface of the cornea, in the vicinity of Schlemn's canal, and that as the disease progresses, a definite peripheral anterior synechia is formed. Unless therefore the iridectomy is made in such a manner that these adhesions are broken away and the iris removed by its root, the iridectomy fails. Achievement of the result is the more difficult, the later the patient comes under operation, hence the unsatisfactory results from late iridectomy.

The majority of cases met with in India are of sub-acute Glaucoma, slowly progressing with a definite increasing contraction of the field of vision. The most successful operation can but stay the disease, and I think it is agreed that there is little or no hope of regaining those portions of the field which have been lost—another reason for early operation.

My object in reading this paper is my desire that through this Section the importance of the diagnosis of early Glaucoma be brought to the notice of those of our profession in general practice, and more especially that the assistant surgeons and hospital assistants in the mofussil should recognise this great importance of operation early in the disease.

I am convinced that Glaucoma is frequently entirely overlooked or only diagnosed when operative treatment is hopeless. When serving in Rajputana, numbers of patients suffering from Cataracts were sent in from outlying dispensaries for operation, but never cases of Glaucoma. When inspecting dispensaries it was the rule to find the eserine bottle unopened, and the atropin almost finished. 80 per cent. of the eye cases entered as conjunctivitis, 10 per cent. as iritis, Glaucoma seldom or never. Yet on enquiry several cases of absolute Glaucoma could be produced from each village.

I have mentioned atropin, that most valuable drug, but nevertheless a drug responsible in India for the loss of many eyes.

I trust I may have the support of the Section in bringing the disease to the notice of the profession, and in asking that it be given more prominent notice than is at present accorded to it in the medical schools of the country.

DISCUSSION.

Captain H. Gidney, F.R.C.S., I.M.S. (Dhubri), agreed with Major Kilkelly in his remark that Glaucoma is not diagnosed early in the mofussil, and suggested adrenalin to prevent hæmorrhage during iridectomy.

Dr. B. H. Nanavati, F.R.C.S. (Ahmedabad):—Iridectomy in an early case gives the best chanee; a large peripheral irideetomy is far superior to a small one. In one case, iridectomy was fairly successful during an acute attaek, the patient having refused operation in the chronic stage. Iridectomy in early cases is the best line of treatment, and gives fair hopes even in acute cases.

Dr. Prabhaker (Bombay):—Thirty years ago Wordsworth said that irideetomy was the best line of treatment, provided it was large and peripheral. But the subsequent loss of vision in chronic Glaucoma, I believe, is due to atrophy of Retina, which thus requires treatment. Iridectomy here therefore is a failure.

Captain Oxley inquired as to when to do iridcetomy and when the filtratiug cicatrix.

Major Kilkelly.—I prefer the filtrating scar in old cases with strong peripheral synœchiœ, where iris is likely to tear off and remain adherent near Schlem's canal. In such cases I might do both the operations and give the patient a double chance. But as I have not followed up the cases, I am not in a position to state the final results.

Dr. Campbell (Jammalamadugu):—I should like to ask what is the opinion of those present as to the advisability of doing a posterior sclerotomy by puncture of the sclerotie with a narrow Van Græfe's knife and letting out a drop or two of vitreous in those cases of Glaucoma where the tension is very high and where the anterior chamber is so shallow that it is difficult to make an incision. I have done posterior sclerotomy in some such cases and have found that it made a difficult operation a very easy one. In the case of subaeute Glaucoma, I think we should carefully look for errors of refraction, particularly hypermetropia accompanied by eye strain. In two cases, in patients of 45, I found uncorrected hypermetropia of + 2 D, with some astigmatism. The patients were quite relieved of their symptoms of Glaucoma by the wearing of properly adjusted spectales.

Captain Gidney:—I have done 7 or 8 cases of posterior scelerotomy, but regret having done so, no good having resulted.

Major Smith (*Jullundur*):—Adrenalin, when its evaneseent vaso-constrictor effects pass off, is followed by a blush, and this blush is liable to be associated with hæmorrhage, and thus I regard it as an agent of doubtful utility in this connection. We come across cases of Glaucoma in which an iridectomy sets up an aeute and uncontrollable Glaucoma. Such cases are rare. I am now trying iustead of an iridectomy the establishment of a subeonjunctival drain, and so far I am satisfied with the results. I reflect a flap of conjunctiva back over the cornea, insert the point of a Græfe's knife perpendicularly and cut out a small plug of selera and make a "button-hole" in the iris beneath it and cover it up with the reflected conjunctiva. I expect the drain to remain patent until the eye has recovered its physiological equilibrium.

That acute Glaucoma is rare in India, I do not agree. It appears so from the faet that patients do not seek our aid early. I would like to know if any one present has enquired into the relation of blood pressure to Glaucoma. I have had a considerable number of cases examined, and so far I can see no definite connection between blood pressure and either Glaucoma or Cataraet.

Major Kilkelly:—Posterior sclerotomy has failed in my eases, and I believe that a small iridectomy might do well. I have been using adrenalin as a routine and never with any bad effeet. My great point of contention is to educate Hospital Assistants to diagnose early, and even then if the patient refuses an operation, if a bad prognosis is given from the start, people here will learn in time to know the gravity. Iridectomy very rarely sets up an acute attack. Removal of a bit of sclerotic as recommended by Major Smith was also advocated by Argyl-Robertson whose recent death we deplore.

Captain Oxley recommended to raise the *general* blood-pressure, which, he said, prevents hæmorrhage during the operation.

Dr. J. Rutter Williamson, M. D., remarked that he had observed the pressure with a Riva Rocci sphygmometer in 15—20 cases of Glaucoma, but none showed an abnormal rise.

Captain Oxley stated that the pressure is low, whilst Major Kilkelly cited a case where it was 220 m.m. Hg. without hæmorrhage. Major Smith remarked that increased blood pressure *has* to do with hæmorrhage, but there is no definite relation. It was remarked that there seems some relation to hypermetropia, because of the congestion of the vessels resulting from errors of refraction.

A DISCUSSION ON THE VARIOUS INCISIONS MADE IN THE

EXTRACTION OF SENILE CATARACT,

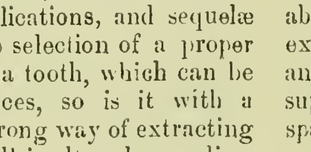
With a Preliminary Reference to the Anatomy and Pathology and the Structures concerned.

By Captain H. GIDNEY, F.R.C.S. (Edin.), D.P.H. (Camb.), I.M.S.,

Civil Surgeon, Dhubri.

In this article I propose to treat of the various recognised operative incisions made for the extraction of a cataractous lens (excluding the congenital variety) and to discuss, as far as my own experience goes, their relative merits. Each author advocates his own particular incision, and the reader is apt to conclude that this incision is suitable for all varieties of cataract, which is far from being the case; for I am of opinion that no one particular incision is suitable for all extractions; in fact, each case must be considered separately, and an incision suitable to its individual peculiarities and requirements should be made. For example, take the two totally distinct operations "Intracapsular" and "Capsule-laceration," the same incision will not do equally well for both these operations; and although the lens can be extracted in both, with a similar incision, yet the difficulties, complications, and sequelæ are considerably influenced by the selection of a proper incision. As in the extraction of a tooth, which can be done either as a whole or in pieces, so is it with a cataract; there is a right and a wrong way of extracting it, and in the same way as your pull is altered according to the situation of a carious cavity when extracting a tooth, so must your incision vary in different forms of cataract operations and in eyes characterised with certain peculiarities; for as no two eyes or cataracts are the same, it follows that they cannot be dealt with alike. Certain broad facts are laid down to guide one, but individual peculiarities creep in in almost every eye, which demand distinctive attention, and the surgeon who attends to this is the one who gives to his patient the maximum amount of benefit. You may be able to extract all your cataracts through one favoured incision, but the point is, could you have done better? Could you have, by varying your incision to suit the requirements of the eye, avoided certain complications, lessened the difficulties, and influenced the sequelæ? It is my belief that the selection of a suitable incision considerably influences the difficulties, complications and sequelæ usually met with in cataract extraction. I would here state that Fig. V, a-b-c-d-e, and Fig VI represent the various incisions under discussion, and as these are made in an area included between 1 m.m. within the clear cornea, and, say, 1 m.m. beyond the edge of the anterior scleral process, *i.e.*, in the sclerotic, it therefore follows that a clear exposition and knowledge of the various structures cut through in this space and their repair under normal and abnormal conditions are absolutely essential to the surgeon who undertakes to extract a cataract, to enable him to compare his results, and to arrive at definite conclusions as to the relative superiority of any one incision over another. This space, *i.e.*, 1 m.m., within and without the cornea might aptly be termed the "play-ground" of the ophthalmic surgeon, for it is here that most operative incisions are executed, and as this article would be incomplete if I omitted to briefly touch on the anatomy and pathology of this region, as far as these incisions are concerned, I must ask for some indulgence while I allude to certain points about the (*a*) Cornea, (*b*) Sclero-corneal junction and (*c*) the Sclerotic.

Fig. I.



(*a*) *Cornea.*—The various layers entering into its formation are so well known that a detailed description of it is not necessary. I would draw attention to Fig. I

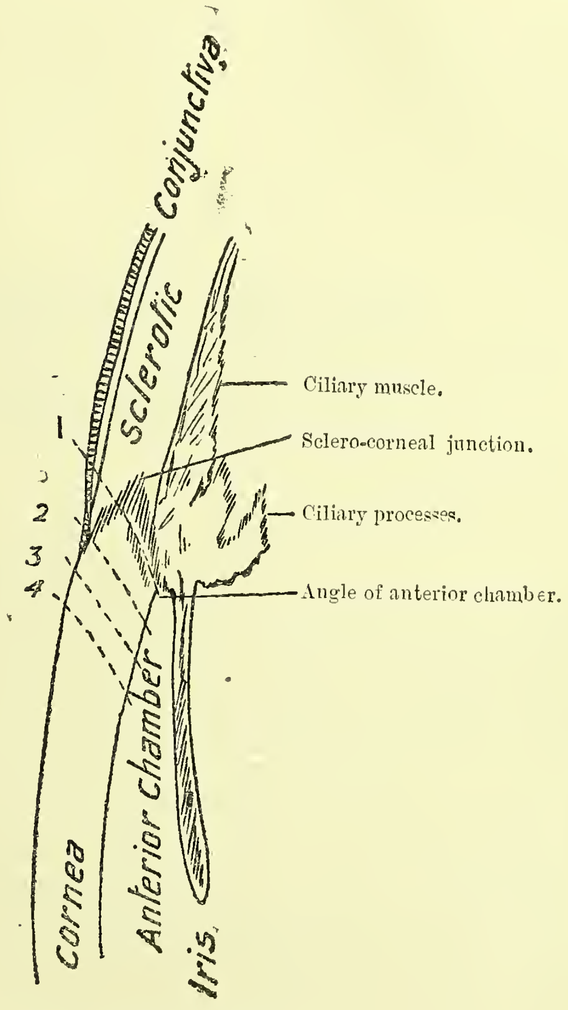
representing (after Gerlack) a transverse section of the cornea. Its division into three main different layers appears to be a most convenient one for a clear understanding of its repair after an incision has been executed. These three layers are external, middle, and internal; the external being epithelial. The middle, consisting of 50 to 60 lamellæ, being the substantia-propria, and the internal being endothelial. Each of these layers plays its own distinctive part in the healing of a corneal incision.

As I shall later on remark that there is a right and a wrong way of making a corneal incision, a few facts about its curvature, &c., would not, I think, be out of place. The cornea, as we know, is merely a spherical projection forward of the sclerotic, and this transition of dense opaque scleral tissue into the beautiful clear cornea marks the outer boundary of a region of very special importance and interest to the ophthalmic surgeon, as it is one where four important structures of the eye meet, *viz.*, the cornea, sclera, iris and ciliary body.

It is important to remember that its anterior and posterior curvatures are not alike. The anterior curvature is irregularly ellipsoidal in shape while the posterior is more regular and closely approaches to that of a sphere. It will thus be seen that these two surfaces cannot be parallel to each other and that the external and internal transverse measurements are not alike. The cornea in fact is set in the sclerotic like a watch glass is in its rim. On the posterior aspect of Descemet's membrane is a single layer of endothelial cells, which is continuous with the layer that covers the ligamentum pectinatum-irides and the iris. The existence of this layer is of importance in those incisions in which a prolapse of the iris occurs.

(*b*) *Sclero-corneal junction or "Corneal falz."*—An accurate knowledge of the anatomy of this junction is of great importance to the eye surgeon, for it is here that most of the operative incisions are performed, *viz.*, for cataract extraction, iridectomy, discission-paracentesis of the anterior chamber, &c. At this juncture the irregular scleral fibres are intimately blended with the clear lamellated corneal tissue and are so arranged that the sclera overlaps the transparent cornea externally in such a way that the edge of the foramen is bevelled at the expense of its interior surface. This bevelling is greater externally than internally, which gives to the scleral limit, when anteriorly viewed, an elliptical shape with its major axis horizontal, and a circular shape when viewed from within. The structures which enter into its formation, from without inwards, are conjunctiva, sub-conjunctival tissue, anterior scleral process, substantia-propria of the cornea, and the posterior scleral process (if developed), with some fibres of the pectinate ligament and an innermost endothelial layer. The posterior scleral process is, as a rule, not so well developed as the anterior, but, when it is, the periphery of the cornea is firmly wedged in between these two scleral processes. This posterior scleral process is of special interest on account of its connection with the structures situated at the anterior angle of the ciliary region, where the iris, cornea and ciliary muscle meet. Fig. II will show the surgical importance of an accurate knowledge of the relations of these various structures to the sclero-corneal juncture. The iris is here seen attached to the posterior

FIG. II.



1. Line of Sclerotic incision.
2. Line of Sclero-corneal incision.
3. Line of Peripheral corneal incision.
4. Line of Valvular incision.

edge of the bevel of the corneal falz. An operative incision at this region, or say a little beyond the anterior process which appears externally at the corneal margin, must necessarily enter the anterior chamber, or space in front of the iris. Again an incision made further away from this edge is very likely to wound important structures such as the base of the iris and ciliary region. If the incision is made still further away, say beyond 2mm., from the corneal periphery, then the posterior chamber of the eye is encroached on and is likely to be opened with an escape of vitreous. The situation of the circulus iridis major, the scleral veins and arteries, also of the

scleral sinus, must be remembered, because these structures are opened up with incisions made too far from the corneal edge and give rise at times to uncontrollable hæmorrhage.

(*c*) *Sclerotic.*—This structure, consisting, as it does, mainly of both yellow and white fibrous tissue, calls for no detailed description. The bridge of scleral tissue extending from the sclero-corneal junction to say 1-2 mm. beyond this in the sclera proper, is the area under review; for it is within this space that some surgeons incise for cataract extraction; moreover, this is the site of the puncture and counter-puncture of my intracapsular incision and for the performance of anterior sclerotomy. The sclerotic at this area affords great support to the structures situated immediately posterior to it, *viz.*, the ciliary region—base of the iris vitreous and the suspensory ligament of the lens. It will therefore be evident that an incision made here deprives these structures of their support, with the result that prolapse of the iris and escape of vitreous are more frequent. The structures cut through in a purely sclerotic incision depend entirely on its distance from the sclero-corneal junction, they are mainly, from without inwards, the conjunctiva, subconjunctival tissue and sclera proper. If the incision is made 5 mm. to 1 mm. from the anterior scleral edge, the knife cuts across the anterior scleral veins which are generally situated quite near the corneal edge. This incision is usually a safe one for it is seldom that any of the important structures, hidden beneath and within the opaque scleral edge, and situated at the angle of the anterior chamber, are wounded; possibly the edge of the knife in its upwards progress may scrape and bruise the iris: this is more likely to happen in an eye with a shallow anterior chamber or a pupil dilated by atropine. An incision made between 1 and 2 mm. from the clear corneal edge encroaches more on the dangerous zone, for the knife cuts through the foraminæ of the anterior scleral arteries, which are situated about 2 mm. from the cornea; moreover the chances are that the knife, in its upward progress, materially injures the ciliary region. The scleral sinus is also cut across. Any incision made beyond 2 mm. is in the *dangerous zone*, and the posterior chamber is likely to be opened up with excessive hæmorrhage. It must be remembered that these structures may be situated much nearer to the sclero-corneal junction in some eyes, and are injured with incisions quite near to the junction. A sclerotic incision is usually located between 5 mm. and 1 mm. beyond the clear corneal edge, and it might therefore appear unnecessary to have entered into the surface anatomy beyond this 1 mm. limit. I have done so because, when performing a sclerotic incision, the surgeon is likely to unintentionally extend it beyond this limit, and it is well to know what structures you have cut, and what dangers you are running into should such an accident happen.

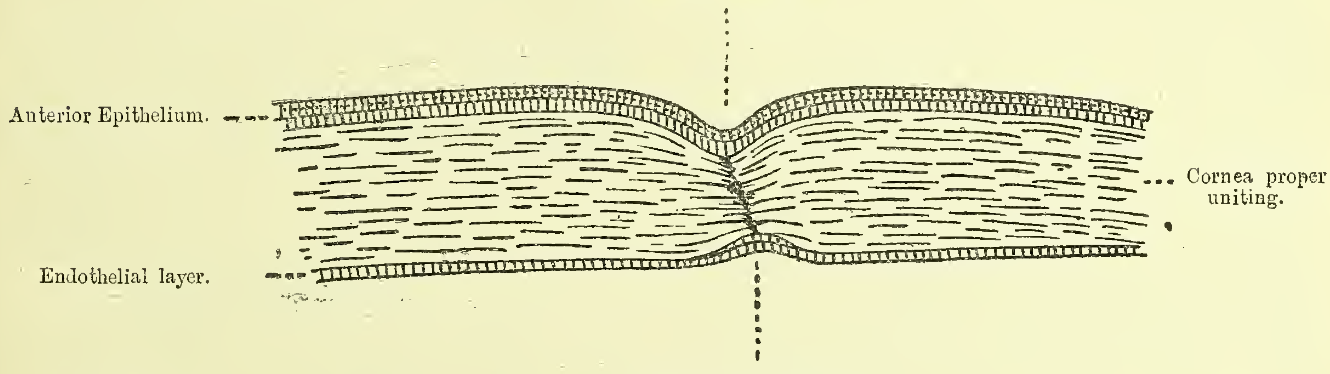
The next point to consider is the process of repair which takes place in these various incisions both under "normal" and "abnormal" conditions.

The purely corneal incision.—I propose dividing these into two classes, *viz.*, (*a*) Uncomplicated, *i.e.*, when healing is normal, and (*b*) Complicated, *i.e.*, when healing is prevented or retarded owing to incarceration between the cut edges of iris, ciliary body, lens capsule, hyaloid membrane, vitreous, retina, or any other foreign body. I shall not touch on the process of repair when septic infection has taken place.

(*a*) *Uncomplicated corneal incision.*—The process of healing is briefly as follows:—After the execution of the incision and the extraction of the lens, the aqueous humour is rapidly re-secreted; this aqueous is more richly supplied with proteids than before, and is now able to form a fibrinous coagulum which plays an important role in the repair of corneal incisions. There are three distinct reparative processes, by which such an incision heals, and which can be differentiated according to the three divisions I have already described in its anatomy, *viz.*, *Epithelial*, *Corneal proper*, and *Endothelial.* The cut edges of the lamellæ of the cornea-proper by imbibing fluid swell up, and come into apposition, this takes place mostly in the central and posterior lamellæ. When the corneal lamellæ are not in contact, the edges of the wound are separated by a clot of fibrinous material, in which a few leucocytes are present. Corneal cells proliferate into this coagulum and push it upwards. This cohesion acts the same as a temporary callus does in a fractured bone. It gets firmer and in time is of sufficient strength to withstand any intra-ocular changes. This union may commence within a few minutes after the incision has been made, and be more or less completed in a short time in very favourable cases; at other times it takes much longer and herein comes the importance of *absolute* rest after a corneal incision has been performed. This is one of "THE" serious drawbacks we labour under in India, for it is the exception to find an Indian patient rest for more than a few hours after operation. When union is delayed, the nutrition of the cornea is at stake, and by absolute rest you afford to the incised cornea the most favourable conditions under which it can speedily and evenly unite. In some corneal incisions the healing is by no means quite regular and even; the proximal lip of the wound is at times overriden by the distal, giving rise to a sort of a riding flap, and, as subsequent cicatrisation goes on, a pulling takes place, which leads to a flattening of the cornea in the meridian at right angles to the incision and a high degree of astigmatism. This irregular healing is not to be wondered at, for so many factors, uncontrollable alike to the surgeon and the patient, act on the cut edges, such as a violent cough, a sneeze, vomiting, straining at stools, a sudden rise in the intra-ocular tension, a violent spasm of the orbicilaris muscle, a violent movement of the head during sleep, or excessive pressure by the hand over the eye during sleep, &c. The irregularity varies in degree and is mainly dependent on the rest afforded. The cornea-proper never regenerates, it is eventually replaced by scar tissue and undergoes the same changes that takes place in scars situated

elsewhere, *viz.*, granulation tissue is developed, from which fibrous tissue fibrillæ are formed leading to a firm compact scar, which becomes less and less evident as time goes on, but which never entirely disappears, eventually leaving only a linear cicatrix. While the cohesion of the *Substantia-propria* is proceeding the external and internal surface of the cornea play their individual parts in the process of repair. These two surfaces, being epithelial and endothelial in structure, and elastic in character, retract after the incision is made, leaving triangular areas, external and internal to the uniting *Substantia-propria.* A glance at Fig. III will show what I mean. This figure represents in a straight line an incised cornea showing an uniting cornea-proper, with external and internal triangular areas or gaps. There is eversion and swelling of the lips of the wound at the external triangular area, due not only to the resistance of this tissue to swelling being felt least here, but also partly to the action of the tears. This triangle sometimes extends half way through the cornea. After some time, generally 24 hours, this external area is gradually filled up by means of an epithelial proliferation, which in time becomes more and more consolidated. The internal triangular area is filled up in a similar manner, but with endothelial product. Finally consolidation occurs within 3 to 7 or 8 days. The cut edges of Descemet's membrane never unite and a new cuticular membrane is eventually developed. In obliquely cut corneal incisions which are valvular in character, the area of contact is greater and cohesion is favoured.

FIG. III.



(*b*) *Complicated corneal incisions.*—It is the experience of all eye surgeons to find a corneal incision not healing normally, and at times, not at all. If these cases were examined carefully by means of a strong lens and a good light, a cause would be found in almost every case; you would observe that some structure is caught between the edges of the wound, it may be iris, lens capsule, hyaloid membrane, vitreous, cilia or other foreign bodies. Most of these can be easily seen, others, such as lens capsule and hyaloid, are not always visible to the naked eye, but, whatever the offending structure is, you will find that the wound is irregular, its external edges appear much swollen and a distinct gap exists; this may be the appearance of the entire incision, or parts of it have healed normally, while other areas have not. Again you might find a distinct movement between the lips of the wound, that aqueous is pouring out, or the anterior chamber is very shallow or absent. The healing of a corneal incision with any of these structures incarcerated between its edges is protracted, may be for days or weeks, and at times it refuses to heal, when the life of the cornea is endangered. The majority of complicated corneal incisions need not be viewed with any considerable degree of apprehension, for healing is usually accomplished after a fashion, but the fact must always be borne in mind that a complicated corneal incision, especially if the iris, ciliary body, or capsular tags are incarcerated, is very liable to septic infection and cyclitis. Lens capsule is particularly resistant to absorption, and such eyes should be carefully watched for some time after healing has been effected.

Take a complicated corneal incision with an iris prolapse. The day after the operation, you find, instead of an almost united wound, one gaping in patches or in its entire extent, with a distinct sulcus between the cut edges. The edges are somewhat œdematous and everted, there is a diffused area of corneal haziness visible on each side of the incision, at one part of it you will see the offending iris, the conjunctiva is injected, varying in degree from slight redness to deep congestion. The rest of the iris does not appear normal. The anterior chamber is either shallow or may be entirely absent, or you might observe a distinct movement of the edges, showing that there is an entire absence of healing. The eye is very painful, there is lachrymation, and photophobia is present; with proper treatment most of these cases progress favourably, and healing, though retarded, is usually accomplished, may be with an excessive degree of immediate astigmatism only, but your prognosis should be very guardedly given even for months after healing has taken place, bearing in mind glaucoma, cyclitis and septic infection as likely sequelæ. As the healing of complicated corneal incisions varies according to what structure or structures are incarcer-

ated between the edges, it would be well to briefly enter into the processes of repair separately. This will be necessary for the purport of this article as I hope to show later on how the selection of an incision influences certain "to-be-expected" complications, and how one can be prepared for and avoid them.

(a) *Iris.*—This prolapse may be partial or complete, a knuckle of it may be incarcerated into the internal triangular gap of the incision, or the entire Periphery may hang outside the wound. Briefly, what happens is that anterior synechiæ are formed, and the iris is anchored in the wound. In time it atrophies, and is eventually replaced by scar tissue, or a cystoid cicatrix is developed. The external surface of the iris is covered and protected by an epithelial layer, varying in density from a very thin exudate to a distinct epithelial membrane. This protective layer is more pronounced and rapidly developed the nearer your incision is to the sclerotic, and much more so when a conjunctival flap has been fashioned. Fragments of iritic tissue may heal in a corneal incision and, except for some delay in healing, give rise to little or no trouble; but the incarceration of a large area is at times attended with grave results, for such wounds, characterised as they are with anterior synechic bands, are always a source of danger to the patient and anxiety to the surgeon, for, during the process of cicatrisation, every movement of this incarcerated iris drags on the ciliary body, leading at times to cyclitic trouble. Moreover, the consolidation of the corneal scar is effected and a weak spot exists, which predisposes the eye to both mechanical and bacterial agencies.

(b) *Lens Capsule.*—Capsular tags when caught in the incision cannot usually be seen by the naked eye, but that this does happen, and more frequently than is imagined, has been abundantly proved by Treacher Collins. As capsule is extremely resistant to absorption, the healing of a corneal incision so complicated is retarded or prevented. The danger being that it forms a track, along which infection from the conjunctival sac can easily travel. These tags are nearly always convoluted and of irregular thickness in sections, due no doubt to the directions in which the capsule was lacerated when the capsulotomy was executed. It is nearly always accompanied with marked lymphocytic infiltration and inflammation, and, as such, there is always the chance of an infection extending to the deeper structures within the eye, leading to cyclitis and what makes it more dangerous is the fact that this cyclitic trouble may arise without any bacterial invasion along the capsular track. One must therefore always view such a complicated incision with great suspicion, and a source of danger to the integrity of the eye.

(c) *Vitreous.*—With vitreous between the edges of the incision the chances of infection are said to be increased. There may be only a bead which may hang in full view outside the incision or it may be seen between the edges, further in. Should an escape have already taken place, then vitreous bands with tags of its ruptured hyaloid may be caught in the wound, an explanation given by some of the distorted pupils sometimes observed after vitreous escapes. It is my experience that the infective risks are greater when a bead of vitreous covered with its hyaloid is caught in the incision than when vitreous, moderate in quantity, has escaped, leaving only a few tags of its hyaloid to be caught between the edges; because in the former you have an entire structure so interfering with the healing of the incision as to cause its edges to gape considerably and to be easily infected, whereas in the latter, union can and *does* easily take place, for I cannot conceive any harm happening to an aseptic incision, whose edges have been burst with vitreous, as occurs with every escape; moreover, it must be remembered that the morphological elements of the vitreous are practically "nil." It therefore follows that one should always excise a bead of vitreous presenting between the edges of the incision. If it is allowed to remain in the wound it becomes invaded with young connective tissue cells derived from the healing corneal edges, and fibrous tissue is developed, which radiates backwards into the vitreous chamber. All may go well with the case, and a pseudohyaloid membrane be developed from the cut edges of Descemet's membrane which grows over the ruptured part of the vitreous.

(d) *Ciliary body.*—A ciliary incarceration usually happens when the incision is purely sclerotic. It is rare in corneal incisions except in those cases in which a large surface of the iris is caught, and during the process of healing it drags, as it were, on the ciliary region, and brings it into the incision (an explanation given to some forms of post-operative glaucoma in a purely corneal incision, when the infiltration angle is blocked up by means of this dragging on the ciliary region). The ciliary body might be outside the incision or merely attached to the internal surface of the wound, where it will not only retard healing, but be a constant source of danger to the eye, owing to the ease of bacterial infection. In such complicated incisions the prognosis is always grave, oftimes calling for excision of the eye. The inflammation set up is intense, accompanied with all the symptoms of cyclitis. In favourable cases a consolidation of the wound takes place, and, except for an irritable eye, the visual result is "fair". But these cases should be carefully watched, and the eye taken out at the first sign of cyclitis manifesting itself, lest sympathetic trouble supervenes, and the life of the sound eye be endangered.

(e) *Retina.*—Should this be incarcerated in the incision, it spells "Panophthalmitis," so any reference to this is not necessary.

(f) *Cilia, Cotton wool fibre, blood clots, &c.*—Any of these structures caught between the edges can be easily seen and should be removed.

(g) *Conjunctival flap.*—Should this be impacted in the incision, it is generally due to the surgeon's carelessness. If it gains a footing between the edges, it may prevent any union whatever, not only on account of it being an epithelial structure, but also because it forms a track for septic infection.

In some corneal incisions, although there are none of the above mentioned structures incarcerated between the edges, yet healing is not only delayed or prevented but is very irregular, and this is due to the part played by the epithelium covering its external surface. In these cases the epithelium from the external triangular area grows in over both edges of the incision for some considerable distance, at times this may pass down into the anterior chamber and even cover the iris and the entire posterior surface of the cornea. These incisions show evidence of normal healing in some areas, whilst in the other places this downward growth of epithelium is very evident and union of a nature takes place, leading to corneal "fistulæ," or there may be no union whatever. These wounds are likely to lead to an attack of glaucoma, and should be watched.

The sclero-corneal incision.—In these incisions, both the sclera and cornea perform their respective parts in the process of repair. I have already described the part played by the cornea, and, as the sclera heals in a similar manner to wounds of fibrous structure situated in other parts of the body, it is needless for me to enter into any details.

In complicated sclero-corneal incisions, the part played by the incarcerated or prolapsed structure is almost similar to what I have already described in complicated corneal incisions. There are certain differences which should be noted, *viz.*, the sclero-corneal junction being a vascular structure, an incision made in this region heals more quickly than in a purely corneal one, moreover you are able to fashion out a conjunctival flap if you so desire, which cannot be done in a purely corneal incision. The conjunctiva being one of the structures cut through in this incision, the epithelial proliferation is greater and more rapid and this helps to cover over and protect any incarcerated structure. This protection is enhanced if a conjunctival flap is made. It will thus be seen that late infection is less likely to occur in sclero-corneal incisions, which is an advantage when operating on an eye with a chronically inflamed conjunctiva and there is a fear of septic infection.

The sclerotic incision.—This being a highly vascular structure, incisions made in it heal very rapidly and afford more of a protection to incarcerated structures and against later septic infection than do sclero-corneal incisions.

The healing of the conjunctival flap is similar to all mucous membrane wounds, and calls for no special description. A description of these four incisions can now be entered into, ascribing to each its particular advantages, disadvantages and relative merits. But, before doing so, it would be well for me to define what I consider to be an *Ideal* incision for a cataract extraction. By an *Ideal* incision I do not mean one that is ALWAYS obtainable, for, as I shall hereafter state, the incision which I consider to be most suitable for an intra-capsular extraction will not do equally well for a capsule-laceration operation, because as with the one incision you obtain certain maximum advantages to counteract certain well-known and "to-be-expected" complications, so in the other incision you lose these to a certain extent, but gain other totally distinctive and separate advantages, to enable you to guard against other "to-be-expected" complications; for example, in my opinion the incision represented in Fig. V.b. and Fig. VI is the most suitable one for an intra-capsular extraction, because in this incision the vitreous receives THE maximum mechanical, physical and anatomical support you can possibly give it, and you are therefore in the best position to guard against and counteract THE most serious and "to-be-expected" complication in this operation, *viz.*, AN ESCAPE OF VITREOUS. It therefore follows that an incision possessing this advantage is superior to one devoid of it. But, decided as this gain is, yet, on the other hand, you loose the advantage of a rapid and effective epithelial protective covering should any iritic tissue be incarcerated in the wound, such as is obtained in the incision marked Fig. V.c. and which, in my opinion, is the most suitable one for a capsule-laceration extraction, because in this situation healing takes place more quickly, and moreover it is possessed of an epithelial layer to protect and counteract some of the "*to-be-expected*" complications met with in this operation—especially "*Prolapse of Iris*" and "*lens capsule.*" It therefore amounts to this:—What you gain in one incision you lose to a certain extent in another, but your gain and loss must be so proportioned and apportioned that you afford to different operations the greatest amount of protection which its "*to-be-expected*" complications MOST require. The various points I put forward as constituting an *Ideal* incision are given only as a guide, and, although you cannot execute an incision possessing all these advantages in their entirety, yet the beginner would do well to bear them in mind when making a selection.

An *Ideal* incision is one which possesses the following points:—

(1) It should be large enough both in diameter and depth to allow with ease the extractions of all lenses.
(2) It should be one easy of accomplishment.
(3) It should be regular—even and cleanly cut.
(4) It should be so shaped as to facilitate healing.
(5) It should be so located that healing is both rapid and strong.
(6) It should not be accompanied with any excessive degree of Hæmorrhage, requiring repeated washing out of the anterior chamber, for in my opinion any incision which requires the entrance into the eye of more instruments than are absolutely necessary suffers from a SERIOUS drawback. (This is one of the greatest advantages claimed by extracting in the capsule).
(7) It should be so situated that it is least acted on by intra and extra ocular-influences.
(8) It should be so fashioned and situated that the resulting Astigmatism is reduced to a minimum.

(9) It should be so situated that the support afforded to important structures within the eye is not seriously weakened.

(10) It should be so located that in its execution important areas are not encroached upon and important structures are not injured or cut across.

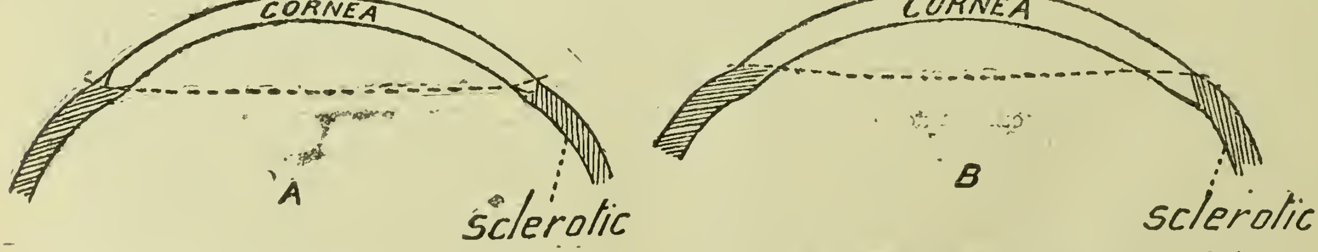
(11) It should be so situated and fashioned as to offer the best protection against septic infection and other sequelæ common to cataract operations.

(12) It should be so located and protected as to possess a maximum bar against vitreous escape and prolapse of the Iris or Ciliary body.

My readers will no doubt say this *Ideal* incision sounds very nice on paper, but is it practicable and can one depend on making an incision possessing all these good points? As I remarked before, this is next to impossible, for not only will you have to vary your incision to suit the operation you have decided on performing, the condition of the anterior chamber, the size of the cornea and the state of the conjunctiva, but the surgeon is confronted with many factors over which he has no control and which render it impossible for him to make his incision *exactly* where he had contemplated doing. For example: say you have decided on performing a sclero-corneal incision, your puncture and counter-puncture have been accurately done and you proceed to complete the incision; when everything appears to be going on splendidly, all of a sudden the patient "screws" up his eye or moves his head, and the direction of the blade of your knife is altered, giving rise to an escape of aqueous; you are now compelled to complete the incision as best you can; it may end in the cornea, or in the sclerotic, in fact at any place but where you intended it to be.

Taking this Ideal incision as a standard I shall now discuss these various incisions, *viz.*, (1) Purely corneal, (2) Valvular (which is partly scleral and sclero-corneal but mainly corneal), (3) Sclero-corneal, and (4) Sclerotic. To Nos. 3 and 4 can be added a conjunctival flap. Fig. V.*a*, b, c, d, e and Fig. VI (the dotted lines) represent these incisions. *The purely corneal incision*: Fig. V.a. This incision can be made at any position from 1 mm. inside the clear cornea to the extreme corneal edge; but, as corneal incisions for cataract are usually executed at the extreme periphery of the cornea, I shall refer to this only when I talk of a corneal incision. A purely corneal incision implies one in which the puncture, counter-puncture and the complete incision are located within the cornea *proper*, and embraces anything up to half of the corneal circle. There is no doubt that this is a favoured incision for cataract extraction, for it is the easiest to perform as the operator sees exactly what he is doing. Moreover, the old time dread of sloughing of the cornea is happily now only of historic importance and interest, for, then, corneal sloughing was ascribed to its loss of vitality, caused by too large an incision, which we now know not to be the cause which is, really, septic infection. The cornea can with safety be incised to the extent of half its circle, but most corneal incisions are somewhat less than this, which is quite large enough for all cataracts outside their capsules. Certain facts must be here remembered, *viz.*, since the anterior and posterior surfaces of this structure are not parallel, the surface dimensions of the incision do not represent the space obtained for the exit of the lens on its internal surface; for, if your incision be not carefully executed and you cut too obliquely, you reduce its internal dimensions, at times to such an extent, that great bruising of the structure is caused and difficulty is experienced in extracting. The lamellated character of the cornea must also be borne in mind, for if you enter it too obliquely the point of your knife, instead of appearing in the anterior chamber and showing its lustre, travels between the corneal lamellæ which is most undesirable. I quite agree with the author who stated that it was not an easy thing to enter the anterior chamber correctly. By "to enter the anterior chamber correctly" I mean an incision which is so situated as regards the anterior and posterior surfaces of the cornea as to give the operator the largest sized wound, as far as the internal dimensions of it are concerned. I would add that just as it is difficult for one (especially a beginner) to enter the anterior chamber correctly, so is it equally, in fact more so, difficult for him to get out of it to the best advantage; because now he has an additional disadvantage, for with the slightest change in the direction of the knife out pours aqueous, shallowing the anterior chamber and increasing his difficulties in making an accurate counter-puncture. This is experienced much more when the left hand is first used for a left eye extraction. A glance at Fig. IVa. b. (dotted lines)

Fig. IV.



Good corneal incision valvular in character. (Somewhat exaggerated.)

Bad corneal incision, knife entered too obliquely reducing internal dimension.

will show (diagramatically) a "good" and "bad" corneal incision (somewhat exaggerated). When the puncture is being made the knife should be held with its point a little less than at right angles to the plane of the cornea; there is then no fear of it travelling along the corneal lamellæ, and moreover the two corneal wounds, anterior and posterior, are almost identical in size as far as their relative surfaces are concerned, and the opening made is somewhat larger. In no other incision is too small an opening more likely to be made as in a purely corneal one. It is much better to make too large than too small an incision, for with too small an opening, excessive pressure is required for extraction, leading at times to an escape of vitreous and much bruising of the tissues; moreover cortical matter, which would otherwise have easily come out with the lens, is scraped off the nucleus and left in the anterior chamber.

Its advantages are the following:—

(1) Easy of accomplishment as the surgeon sees exactly where he is cutting.

(2) It can be regular and evenly cut if the knife be sharp.

(3) If at the summit of the incision the knife is made to cut obliquely and then directly forwards, a valvular character is imparted to it, and healing is rapid and regular.

(4) There is no hæmorrhage to obstruct the view or to require the use of the Irrigator.

(5) Important structures are not encroached upon or cut across.

(6) More support is given to the base of the Iris, Ciliary region and Vitreous, and the percentage of Iris prolapses and Vitreous escapes is less than in sclero-corneal and sclerotic incisions. This advantage increases the lower down in the clear cornea the incision ends from the corneal periphery. I would here state my confirmed opinion that the nearer your incision approaches to the sclerotic, the higher is your percentage of Vitreous escapes and Iris prolapses, and *vice versa*.

Its disadvantages are the following:—

(1) A beginner is likely to make too small an incision and to push the knife through the corneal lamellæ.

(2) The cornea being a non-vascular structure healing is not so rapid as in sclero-corneal and sclerotic incisions.

(3) Should any structure be incarcerated in the incision, the epithelial protection which is so necessary is very sparingly and slowly developed, in fact it usually consists of a thin exudate, which is insufficient as a protection against later sceptic infection and Iritic and Ciliary trouble.

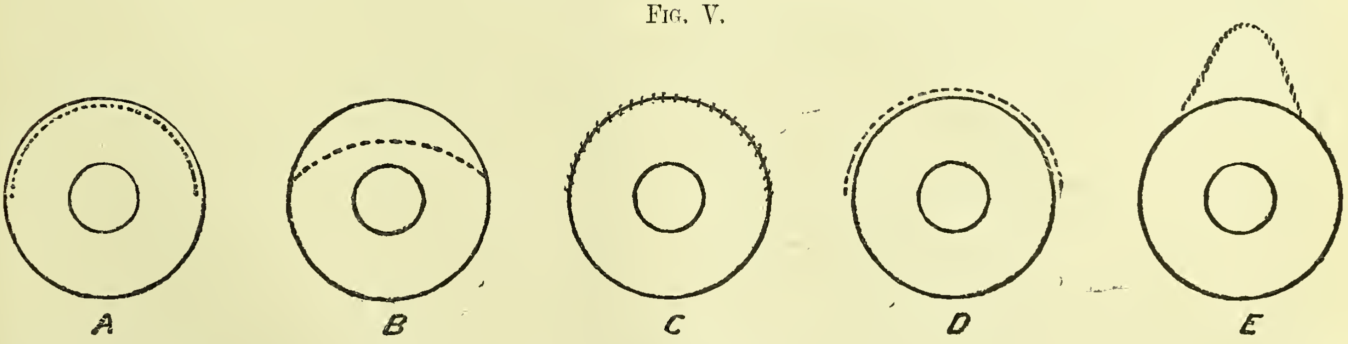
(4) It is more easily acted on by intra and extra ocular influences, on account of its slower union, as against the rapid healing of sclero-corneal and scleral incisions.

(5) The corneal epithelium is likely to grow in between the edges of the incision, which not only retards union, but at times entirely prevents it and so exposes the eye to septic infection.

(6) Your inability to make a conjunctival flap. On this point I would remark that, if the anatomy of the corneal layers be examined, you will observe it is impossible for the surgeon to make a conjunctival flap in a *purely* corneal incision, unless he cuts through the sclero-corneal junction, when his incision can no longer be called a PURELY corneal one. In some works you do read of a corneal incision with a conjunctival flap, but this is inaccurate. The attachment of the anterior epithelial layer of the cornea to Bowman's membrane is too intimate to allow of any separation being possible by the knife. Moreover it must be remembered that there is no sub-conjunctival tissue beneath the anterior epithelial layer of the cornea, as exists under the conjunctiva in the sclero-corneal and scleral regions. The existence of this sub-conjunctival layer is necessary for the execution of a conjunctival flap in sclero-corneal and scleral incisions, for there are occasions when this layer is absent, and the conjunctiva is so closely attached to the sclera that you are unable to fashion out a conjunctival flap.

(7) *A higher degree of astigmatism.* On this point I would remark that it is impossible to lay down any hard and fast rule as to the relative degree of astigmatism which results from any particular incision, or to ascribe to it any important advantage. The amount is bound to vary, not only on the location and the extent of the incision made, but it is influenced by any subsequent increased or diminished intra ocular tension, by any accidents which might happen during or after the operation, such as irregular healing of the wound,

FIG. V.



Peripheral-corneal. Valvular. Sclero-Corneal Sclerotic Conjunctival Flap.

impaction of capsular tags, prolapse of iris or ciliary body, or with any subsequent inflammation that may take place. As these accidents are likely to occur in ANY incision (more often in some than in others), it happens, at times, that the astigmatism in a normally healed corneal incision (which is said to cause a higher degree of astigmatism than sclero-corneal scleral wounds but which is particularly immune to iris prolapse) is less than in a sclero-corneal, complicated with *even* a slight iris prolapse. When stating that any particular incision has the advantage of a lower degree of astigmatism over another, one must not take into consideration the actual degree of it only, but also its *regularity* or *irregularity*; for instance, it is accepted that a certain degree of astigmatism ALWAYS results after all cataract extractions, no matter which incision is made; take a sclero-corneal or a scleral incision in which the chances of an iris prolapse are greater, but the degree of astigmatism is, as a rule, said to be less than in a purely corneal one; in such an incision, complicated with even a small iris prolapse, the degree of astigmatism, although it may not be as high as in a fairly well healed corneal incision, is nevertheless more *irregular*. It is therefore obvious that it is not the actual degree of astigmatism, caused by an incision which should concern us so much as its amount of irregularity. Regular astigmatism can be corrected with suitable cylindrical lenses, but there are many cases of irregular astigmatism developed after a cataract extraction, which defy correction. My experience is that the location of the incision does not influence the resulting astigmatism to any marked extent. It depends mainly on the manner of healing, the rest afforded to the eye, and the behaviour of the patient after the operation. Contrary to all teachings on the subject, I have often found that the incision which I advocate for intra-capsular extraction, and which is mainly corneal, does not produce as high a degree of astigmatism as I have at times observed after a sclero-corneal incision with a conjunctival flap.

In India, as most of our patients are illiterate villagers to whom a degree or two of extra astigmatism makes very little if any difference, this drawback in an incision becomes a "quantite negligeable." Having discussed this incision, the question arises, in what cases is it suitable and unsuitable?

It is suitable in every extraction in which it has been decided to lacerate the capsule, especially if you are not in favour of the irrigator or not absolutely certain of its asepsis, (*b*) in liquid cataracts, (*c*) when you wish to avoid an escape of vitreous.

It is *unsuitable* (*a*) when the cornea is abnormally small,

(*b*) when the conjunctiva is chronically inflamed, perhaps insufficiently treated and possibly still containing pathogenic bacteria,

(*c*) when there is a chronic granular conditions of the lids,

(*d*) when there is any fear of subsequent septic infection,

(*e*) when the patient is a restless one or suffering from Anæmia, Asthma, Chronic Bronchitis, or Insanity,

(*f*) In Intra-capsular extractions, owing to its small diametric measurement.

(2). *Valvular Incision.*—Figure V (*b*) and Fig. VI.—In this the puncture and the counter-puncture are made in the sclera 5 to 1 mm. beyond the sclero-corneal junction, but the rest of the incision is purely corneal. The name "Valvular" may sound peculiar, but it best suits the description I shall give of it. It is performed as follows :—The point of the knife is inserted in the sclerotic 5 mm. beyond the sclero-corneal juncture on the temporal side and from 1 to 2 mm. above the horizontal meridian of the cornea, is passed slowly across the anterior chamber and is made to emerge at a corresponding point and level on the nasal side, this constitutes the puncture and counter-puncture. The rest of the incision is completed with one or two to and fro movements of the knife and ends in the clear cornea, a little above the point, corresponding to the junction of the upper and middle thirds of the upper half of the cornea. In the upward progress, the knife should, as it were, hug the sclero corneal junction for a VERY short distance, when it leaves this to cut out into the clear cornea. At the summit of the incision, the cutting should be quite leisurely accomplished, the edge of the knife being turned somewhat obliquely, and when almost through the cornea it should be turned directly forwards. Fig. VI clearly shows the line of incision. An incision so fashioned is an irregularly curved one, its temporal and nasal ends (at the scleral region) being as if they were parts of the arc of a larger circle than the corneal part of the incision. A valvular character is also imparted in that its area of contact is greater and cohesion is favoured. The incision requires to be seen to be properly understood, the various movements following each other so quickly are difficult to describe. This is the incision I always perform in Intra-capsular extraction of mature and immature cataracts. It would be "splitting hairs" to say that it is much different to the one Major Smith advocates, but nevertheless there are some slight differences, for it is somewhat larger and irregularly curved, and when healed, is always hidden under cover of the upper eyelid. The advantages and disadvantages I shall ascribe to it will be with special reference to its suitability and superiority over other incisions as regards the intra-capsular operation *only*. Its advantages over a peripheral corneal incision are : (*a*) the puncture and counter-puncture being in the sclera, the base of the opening obtained is large and extraction of the lens in its capsule is facilitated ; this is required, for it must be remembered that a lens in its capsule is a bigger object to extract than one whose capsule has been lacerated, and when only the nucleus with some adherent cortical matter requires extracting (the

enormous difference between the size of the lenses is what strikes one so much at his first intra-capsular operation). While on this point I would remark that the part of an incision which influences the easy exit or otherwise of the lens is mainly its diametric dimensions, and to a slight extent its upward limits, or depth, for it matter very little whether your incision includes the upper half of the corneal circle or not, yet difficulty will be experienced in extracting the lens if the diameter of the incision does not include at least the entire horizontal (or as near to it as possible) meridian of the cornea (I exclude congenital and liquid cataracts which require a smaller incision). It is therefore apparent that an incision which gives the maximum opening is the one which will allow an easy extraction of a lens in its capsule. (*b*) As it extends through a vascular structure in a part of its course and receives an extra epithelial protection, the process of healing is necessarily more rapid at least at the sites of puncture and counter puncture. Moreover with the puncture and counter puncture more readily uniting, it is obvious that there is a better chance of the purely corneal part of it uniting more regularly and speedily, for these two vascular points of union act as a pair of distant SPLINTS, checking to some extent the "give" of the corneal edges to any intra or extra-ocular influences. (*c*) There is a little hæmorrhage at the points of puncture and counter puncture, but this favours healing more than obstructing any view. (*d*) Except for the puncture and countor puncture, the incision is easily executed. (*e*) Being valvular in form the corneal edges easily fall back into position and remain in contact. (*f*) The chief advantage of this incision is the fact that your percentage of vitreous escapes is considerably reduced, for here you have a wound consisting of 2 flaps; an upper one consisting of about 1 mm. of clear intact cornea attached above to its sclero-corneal juncture, and a lower of the remaining portion of the cornea; when the strabismus hook is used and the lens appears at the wound, your incision has the appearance of a valvular opening, so situated that the upper flap offers the strongest mechanical bar against an escape of vitreous. The upper part of the suspensory ligament has by now ruptured when the lens appears at the wound, and as it advances forward its place is occupied by the vitreous enveloped in its hyaloid membrane. The appearance of the vitreous in such a wound is prevented by the upper "ledge," so to speak, of corneal tissue; for it is now, since the lens moved forward into the wound, supported by its hyaloid membrane, iris, and this 1 mm. of intact corneal tissue. In fact there does not seem to be room for any vitreous to appear at the wound before the lens is entirely out or almost so. The incision seems to be large enough for the lens and IT only, and it is my experience that when an escape of vitreous does take place with this incision, it happens after the extraction of the lens, for as far as I can remember, in nearly 1,000 "intra-capsulars" which I have performed, there have been very few escapes of vitreous before the lens was entirely, or almost entirely, out. What is it that so influences the vitreous escapes? Unless some of my readers have a better explanation to offer, it is my opinion that this is due "*solely*" to the situation of the incision, and the mechanical and anatomical support it affords to the vitreous. Compare the above with what so often happens when a peripheral corneal or sclero-corneal incision is made for an intra-capsular extraction. When pressure is applied with the strabismus hook and the lens appears at the wound, it presents itself in a peculiar position, not close to the upper limit of the incision, but a little lower down the operation field; in fact at the site where your incision would have ended (its summit) had the one I advocate been executed: more pressure than is usual seems to be necessary to set the lens in motion, and as it presents itself more and more at the wound, a clear view of its posterior surface is obtained with a bead of shining vitreous, bulging as it were and stuck to the posterior capsule, asking to be allowed to come out, which it very often does, and at times before the lens has been extracted. I have given these two incisions an exhaustive trial in my intra-capsular extractions and have no hesitation whatever in stating that the nearer your incision is to the periphery of the cornea and sclera, the higher will be your percentage of vitreous escapes, and *vice versa.* At first my vitreous escapes without selection averaged from 18 to 22 per cent., whereas now with a properly made incision and more experience, I have reduced them to about 10 por cent.; moreover with this incision I have performed series of 39 and 22 consecutive intra-capsular extractions, without even a bead of vitreous escaping either during or after the operation.

(*f*) Another advantage is that a prolapse of the iris is less frequent. *The disadvantages are the following:*—(*a*) Except at the points of puncture and counter puncture, healing is not so rapid as in a sclero-corneal or scleral incision. (*b*) Moreover except at these points you do not supply to the incision and the eye, the protection afforded by sclero-corneal and scleral incisions, with regard to the epithelial covering, should any structures be incarcerated between the edges. (*c*) Inability to execute a conjunctival flap and so enhance the epithelial protective layer.

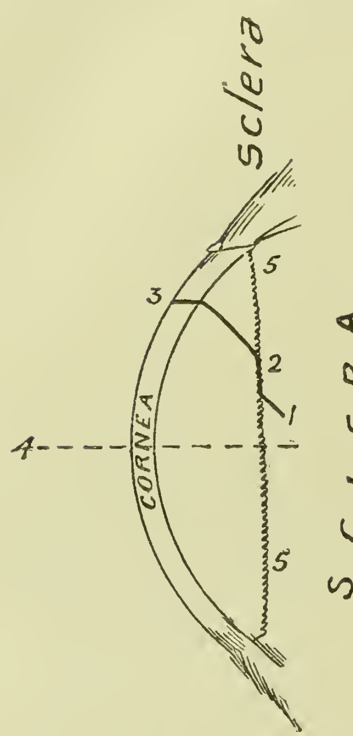
(3)—*Sclero-corneal incision*, Fig. V (*c*).—Here the puncture, counter puncture, and entire incision are made exactly in the sclero-corneal junction, with or without an additional conjunctival flap, as desired. The structures cut are, from without inwards, the conjunctiva anterior scleral process—substantia-propria of the cornea, and posterior scleral process (if well developed) with the posterior endothelial layer.

The advantages are:—(*a*) The diameter of the opening obtained is larger than in a corneal incision, and therefore no difficulty is experienced in the extraction.

(*b*) The entire incision being made in a vascular structure, healing is more rapid, and stronger.

(*c*) Post operative glaucoma is less frequent, especially if a conjunctival flap has been cut out, owing to the formation of a filtering cicatrix. A very active filtration

FIG. 6. VALVULAR INCISION.



1. Site of puncture in sclera 5 m.m. from Sclero-corneal junction.
2. Part of incision hugging sclero-corneal junction for a very short distance.
3. Summit of incision ending in cornea just above junction of upper and middle thirds of upper half of cornea. Note the line produced by turning cutting edge directly forwards.
4. Line drawn through centre of eye to represent the horizontal meridian.
5. Sclero-corneal junction.

cicatrix may lead eventually to a soft-eye with marked minus tension.

(*d*) The conjunctiva being cut throughout the incision a rapid and effective epithelial protection is afforded to any incarcerated structure, much more so if a conjunctival flap has been added.

(*e*) With this protective covering the changes of late septic infection of the eye are materially reduced.

(*f*) If executed properly it is a regular, clean, and even cut.

(*g*) It is not so easily acted on by intra or extra-ocular influences as corneal incisions.

Its disadvantages are:—(*a*) It is not very easily accomplished, and the operator cannot always depend on cutting exactly through the juncture; you are likely to cut too far into the sclerotic, with excessive hæmorrhage, which will require the use of the irrigator, and, although it can be safely washed out of the anterior chamber, yet it is not a desirable accident to happen, especially if you are not in favour of irrigation, or you may cut too far forward into the clear cornea. (*b*) The iris, ciliary body and vitreous lose their support to a considerable extent, and there is a higher percentage of vitreous escapes and iris prolapses.

Its suitability.—(*a*) If you are *absolutely* certain of your asepsis as regards the irrigator, this incision, aided with a conjunctival flap, is in my opinion the IDEAL one for a capsule-laceration extraction. (*b*) It is more suitable than a purely corneal incision in an eye with an abnormally small cornea. (*c*) When the conjunctiva is not very healthy. (*d*) In bronchitis, asthma, and restless patients. (*e*) When there is any dread of secondary septic infection. It is *unsuitable in* (*a*) intra-capsular extraction for the same reasons as given against a peripheral corneal incision, but in an exaggerated form, because here your cut is nearer to the sclerotic, and the loss of support to the vitreous is greater though the diameter of the incision is somewhat larger. (*b*) When the anterior chamber is VERY shallow, because, in this incision, the level of your knife is at a lower depth than in a purely corneal one, and the iris is likely to be bruised or cut, more especially if the pupil has been previously dilated, a practice resorted to by some surgeons.

(4) *Sclerotic incision*, Fig. V (*d*).—In this the puncture, counter-puncture and entire incision are made in the sclera proper, that is, at any site between the sclero-corneal junction and 1 to 2 mm. beyond it in the scleral tissue. Advocates of this incision for cataract extraction, usually make it at any situation between ·5 and 1 mm. from the corneal periphery. Some go further into the sclerotic. The structures incised are from without inwards, the conjunctiva, subconjunctival tissue, and the entire sclerotic. Should the incision be made too far in the sclera the base of the iris, in fact, the ciliary body, is either cut or bruised by the edge of the knife, and, if placed still further back, the posterior chamber of the eye is opened up The anterior scleral arteries and veins and the scleral sinus are also cut across.

The *advantages* of this incision are :—(*a*) The sclera being a highly vascular structure, healing is very rapid and firm. (*b*) A larger opening in its transverse measurement is obtained than in any of the preceding incisions, and there is less bruising of the structures during the extraction, which is easily accomplished. (*c*) Being a highly vascular structure, and the incision possessing as it does a conjunctival flap in its entire extent, it affords a strong protection against late bacterial invasion. This qualification renders it a very suitable incision in an eye with a chronically inflamed conjunctiva.

Its disadvantages are:—(*a*) *Hæmorrhage.*—This is nearly always considerable, and at times uncontrollable, so much so, as to fill the anterior chamber again and again, which not only requires the repeated use of the irrigator, but hides from view the field of operation, and seriously menaces healing. If the incision be located ·5 mm. within the sclera, the hæmorrhage is not excessive; nevertheless, it will still require the constant use of the irrigator, but the surgeon cannot always depend on cutting within this 5 mm. limit, the patient may move his head, or "screw" up his eye, and so alter the direction of the blade of the knife that the incision is completed beyond

this safe limit and may enter the dangerous zone. (*b*) It is not easy of accomplishment, as a surgeon cannot exactly see where he is cutting, and the puncture and counter-puncture might be placed too far forwards or backwards. (*c*) The level of the knife being at a lower depth than in any of the preceding incisions, it has very little room in the anterior chamber to "*play*" about, and there is a greater chance of the iris being cut or bruised in the entire extent of the incision, thus increasing the hæmorrhage, and converting what should have been a painless into an acutely painful operation. The patient resenting this pain, "screws" up his eye more and more, which in itself prevents you making the incision within safe limits. This is experienced much more when the anterior chamber is shallow. (*d*) The fear of completing the incision too far in the sclera and opening up the posterior chamber of the eye, with an escape of vitreous before the lens has been extracted. (*e*) The greatest disadvantage is the loss of support to the underlying structures, *viz.*, ciliary body, iris and vitreous, more especially if the knife cuts out a large coloboma at the base of the iris. This is a very serious disadvantage, for, on applying pressure to extract the lens, there is likely to be a vitreous escape before the lens is out, and I need not dilate on the seriousness of such an accident happening. (*f*) A greater frequency of prolapse of the iris. (*g*) Development at times of a soft eye with reduced tension.

This incision is unsuitable in intra-capsular extraction for the same reasons as given in corneal incisions, and more so, because the support to the vitreous is further weakened. It is not one that I would adopt in capsule-laceration operations, except under certain circumstances, when it is pre-eminently suitable, *viz.*, (*a*) an abnormally small cornea, (*b*) a chronically inflamed condition of the conjunctiva and granular lids, (*c*) should you have any dread of later septic infection taking place.

(5) *Conjunctival flap*, Fig. V (*e*).—To both sclero-corneal and scleral incisions a conjunctival flap may be added. This flap may be varied in size from 1 to 3 or 4 mm. long. It is generally made at the summit of the incision, although you are likely to cut it a little to the one or other side of the vertical meridian. The edge of the knife after it has cut through the sclero-cornea or sclera, is turned obliquely upwards and carried under the conjunctiva (in the sub-conjunctival tissue) for any desirable distance when it is made to cut out.

The *advantages* of a conjunctival flap are:—(*a*) Being a vascular structure and uniting rapidly it helps the incision to unite quickly, firmly and to withstand any sudden rise in intra-ocular tension, or a violent attack of coughing, or movement on the part of the patient. This is of great value in India with uneducated patients, who will not rest after the operation. (*b*) It acts as a powerful additional protection against late bacterial invasion. (*c*) Should the iris or ciliary body be prolapsed, it increases the epithelial protective layer and helps to reduce their evil suquelæ to a minimum. (*d*) It is "par-excellence" the incision in Indian mofussil eye surgery, when the patient may be required to walk miles, back to his village, a few hours after the operation.

Its disadvantages.—(*a*) A certain degree of hæmorrhage which nearly always demands the constant use of the irrigator. (*b*) Filtration chemosis is more likely to happen, which, although not exactly dangerous, is a very alarming and undesirable complication. (*c*) It is likely to become inverted and caught between the edges of the incision and retard healing. (*d*) When the flap is turned over the cornea at its corneal attachment, as should be done, it prevents one from locating the iridectomy accurately.

Having described and discussed these various incisions I am now in a better position to state my opinion.

It is my belief that sufficient attention and importance are not given to the *incision* in cataract operations. A correct incision so influences the difficulties, complications, and after results of an extraction, that the surgeon should carefully consider each case, and apply to it the incision which is most suitable, and not be content with performing one particular and favoured incision to the exclusion of all others, in every variety of cataract and eye.

A few broad questions can now be discussed. Can any one particular incision be suitably adopted as a *standard* for all extractions? In my opinion this is not only impossible but incorrect surgery. This question can be best approached by dividing extraction of cataract into two distinct operations, *viz.*, (*a*) intra-capsular, and (*b*) capsule-laceration, and then applying to each of these the advantages and disadvantages already ascribed to the various incisions, and observing how the USUAL difficulties and complications of each operation are best prevented and counteracted by any particular incision.

To take the intra-capsular operation first. Now what are the chief difficulties, complications and sequelæ usually experienced in this operation which the selection of a correct incision would materially lessen or an unsuitable incision considerably increase (I exclude bursting of the capsule)? These are (*a*) too small an incision necessitating excessive pressure being applied with all its disasters, (*b*) irregular and delayed healing, (*c*) astigmatism, (*d*) vitreous escape.

(*a*) *Too small an incision.*—This difficulty is more likely to be experienced if a purely corneal incision be made. The incision in Fig. V (*b*) and Fig. VI is a much larger one, as its diameter extends beyond the sclero-corneal juncture. A cataract in its capsule is a big object to extract, having a diameter of 9 mm and a thickness or depth of about 5 mm. and requires an incision embracing more than the transverse diameter of the cornea. As the valvular incision affords a large enough opening, it is therefore suitable, and in selecting it this difficulty is overcome.

(*b*) *Irregular and delayed healing.*—As this depends on so many factors, it would hardly be fair to include it as a serious disadvantage to any one particular incision, but nevertheless it is quite true that an incision situated in a vascular structure, such as the sclero-corneal junction or sclera, especially if aided with a conjunctival flap, does heal more rapidly and firmly than one situated in the cornea. It therefore follows that a purely corneal incision

would not be so suitable in this operation as a sclero-corneal or scleral. The incision in Fig. V (*b*) and Fig. VI, being partly vascular, has a better chance of healing more rapidly than a purely corneal one, and does not suffer from this drawback to such an extent; it is therefore NOT unsuitable in this operation, but at the same time it does not carry with it the same protection against this complication as a sclero-corneal or scleral incision.

(*c*) *Excessive Astigmatism.*—As this is almost ENTIRELY dependent on the manner of healing, the remarks entered against "Irregular and delayed healing" apply with an equal amount of significance as regards the influence a properly selected incision has on the resulting Astigmatism in this operation. (I would draw attention to the remarks I have already made on this when discussing it as a disadvantage in a corneal incision.)

(*d*) *Vitreous Escape.*—I admit that this complication varies according to the experience and skill of the operator and his assistants and inhibition of the extrinsic ocular muscles, etc., but nevertheless the situation of the incision DOES possess a MARKED influence on it. For an incision to influence this complication it must afford support to the vitreous; if this is not supplied an escape is more likely to occur. On this point take a corneal or a sclero-corneal incision and compare its influence with that of my incision as represented in Fig. V (*b*) and Fig. VI. In the former the upper limit is situated at the periphery of the cornea, which in itself deprives the vitreous of a great amount of support; it therefore follows that if either of these incisions be made in an intra-capsular extraction, the percentage of vitreous escapes is sure to be a high one (30 to 40 % as estimated by some surgeons), and the influence it bears must consequently be one which considerably increases this complication. Compare this with what is obtained by making an incision as is represented in Fig. V (*b*) and Fig. VI. Its situation is such, that there is an upper flap of about 1 mm. of intact cornea; this bridge of tissue together with the Iris act as a support to the vitreous, and a bar against it escaping. The percentage of escapes is reduced to a much lower figure; not only this, but less pressure appears to be necessary for extraction, and the lens seems as it were to slip out from the incision; but, great as this advantage is, this incision suffers from a drawback in Intra-capsular extraction, *viz.*, the Epithelial protection so desirable, especially when vitreous has escaped or any structure is prolapsed, and which sclero-corneal and scleral incisions possess, is not developed to any appreciable extent, except at the sites of the puncture and counter-puncture. Most authorities state that septic infection is more likely to occur when vitreous has escaped; this might be so, it awaits proof, but the fact is we do not always expect septic infection as adequate precautions are always adopted, so why should this be anticipated? Why should we deprive an incision, such as the one I advocate, of its chief advantageous qualification, required to counteract THE most serious and dreaded drawback in Intra-capsular extraction, *viz*, VITREOUS ESCAPE, and locate it, say, at the sclero-corneal junction, simply to be protected against the remote possibility of septic infection? If septic organisms are present infection will take place, no matter which incision is made. Moreover, if a sclero-corneal incision, with or without a conjunctival flap, is used in this operation, the amount of hæmorrhage would necessitate the constant use of the irrigator, and irrigation is, in my opinion, not only absolutely unnecessary, but at times harmful in Intra-capsular extraction. It would be well to remark here on the effects of irrigation with sterile saline solution in some cases of capsule-laceration operation. For a day or two after the extraction the anterior chamber appears as if covered with a thin layer of lymph, and, as Col. Maynard points out in his excellent account on Irrigation (page 68, "Manual of Ophthalmic Operations" by Maynard), "the condition appears alarming until one gets used to it, as it all clears up." If sterile saline has this effect on the cornea, what is likely to be its action, if any, on such a delicate structure as the Hyaloid? (I have never used it in this operation and would like to be enlightened on the point.)

Another aspect, say vitreous has escaped or the capsule has burst *together* with a vitreous escape; now if the incision be a sclero-corneal one with a conjunctival flap and irrigation be attempted, just picture to yourself the mixture produced of vitreous, lens cortex, blood and saline. Even if irrigation has not been attempted (and this should never be done with an escape, in fact it is impossible to irrigate without further endangering the safety of the eye) the admixture of the lens cortex and vitreous is bad enough, but this becomes worse when blood is added to it.

In a nutshell it amounts to this:—In an Intra-capsular operation if you perform a valvular (Fig. V (*b*) and Fig. VI) incision you reduce your percentage of vitreous escapes and Iris prolapses considerably, but you lose to a certain extent an Epithelial protective layer, whereas, if you do a sclero-corneal or scleral incision, you increase your vitreous escapes and Iris prolapses to 2 to 3 times the number, but gain an Epithelial layer (which is more needed in these incisions, to guard against infection taking place along the track of any prolapsed structure). Now, assuming that septic infection is practically excluded, I put the question—Which is the most suitable incision for an Intra-capsular extraction? Personally, I am of opinion that a corneal, sclero-corneal, or scleral incision is just as "*unsuitable*" for an Intra-capsular extraction as any one of them is "SUITABLE" in a capsule-laceration operation, also that although the incision I advocate (Fig. V (*b*)) does not possess all the points constituting an *ideal* incision, yet it is the *most* suitable one for an Intra-capsular extraction.

Now take the other operation, *viz.*, *capsule-laceration*, and treat it in the same way as has been done with Intra-capsular. What are the chief difficulties, complications and sequelæ in this operation which are influenced by the selection of a suitable or unsuitable incision? These depend on the incision made and vary accordingly, but broadly they are—

(*a*) Too small an incision, (*b*) Prolapse of Iris or Ciliary body and an entanglement in the wound of tags of lens capsule (*c*) Irregular healing, (*d*) Escape of vitreous.

(*a*) *Too small an incision.*—This difficulty is usually experienced when the incision is a purely corneal one and the knife is entered too obliquely; but this operation, as only the nucleus of the lens together with any adherent cortical matter is extracted, does not require such a large incision in its transverse measurement as for Intra-capsular extraction. An incision comprising the entire diameter of the cornea 1 to 2 mm. above the horizontal meridian is more than large enough for all cataracts (outside of their capsules).

(*b*) *Prolapse of Iris, Ciliary body, and capsular tags.*—I take it as accepted that the Iris prolapses more frequently in peripheral corneal, sclero-corneal and scleral incisions than in those made lower down in the clear cornea. With this acceptance it follows that the selection of a suitable incision has a great influence on this complication, and that it should possess a strong and rapidly developing Epithelial protective layer. This is obtained by adding a conjunctival flap to your sclero-corneal incision. The dangers of Iris prolapse are not only immediate, such as retarding healing, irregular healing, iritis, &c., but also remote, especially secondary septic infection. An incision located in a vascular structure, and aided by a conjunctival flap, prevents these dangers to a very great extent, and should always be performed in a capsule-laceration extraction. Moreover, in this operation the capsule is lacerated, may be in 2 or 3 directions and the tags in the upper half being carried upwards during extraction, are frequently caught between the edges of the incision. Swanzy estimates that he has found these tags in 25 % of his capsule-laceration operations. I do not think I would be far off the correct figure if I put it at 50 %. We know that lens capsule is peculiary resistent to absorption, and with such a high percentage, as even 25 %, there is very little doubt we have here the chief cause of irregular or delayed healing in capsule-laceration operations when the toilette of the incision has not been carefully attended to. We have, moreover, in this a very strong and additional reason why in this operation our chief object should be to perform an incision which not only heals quickly but possesses in a "*marked*" degree an effective ephithelial protective layer.

(*c*) *Irregular healing.*—This is less likely to happen the more your incision encroaches on vascular structure and *vice versa.* There are two factors which influence the amount of irregularity, *viz.*, location of the incision, but mainly the incarceration of any tissue between the edges of the wound. The same remarks, therefore, practically apply to this as to the preceding complication, and an incision best protected against such healing is the most suitable one. The regularity of healing is somewhat enhanced in incisions possessing a conjunctival flap.

(*d*) *Vitreous escape.*—The incisions usually made in this operation are a peripheral corneal or a sclero-corneal, both of which deprive the vitreous of some of its support and would, on this account, appear at first to be unsuitable incisions, but there is a great difference between this operation and Intra-capsular extraction as regards the support afforded to and required by the vitreous, *viz.*, whereas in an Intra-capsular extraction the vitreous has to rely on the Iris and cornea ONLY for its support, in a capsule-laceration operation it enjoys the additional support afforded by the posterior capsule and suspensory ligament, structures which are left intact. This explains to a certain extent why in an Intra-capsular extraction a low corneal incision with a 1 mm. flap of intact cornea is more suitable, offering as it does a bar against vitreous escapes, and why an incision devoid of this corneal flap so to speak, in fact its very opposite in every way, is on the other hand the most suitable in a capsule-laceration operation.

Moreover, as the capsule is lacerated in this operation, very little pressure as compared with an intra-capsular is required to extract the lens, and the vitreous, therefore, in a way, does not need so much support as it *does* receive. Escape of vitreous forms a negligeable complication in this operation, for 3 to 4 per cent. is the highest an experienced surgeon would have; such escapes as do occur are generally due to too small an incision being made, necessitating excessive pressure for the delivery of the lens, a weak suspensory ligament, fluidity of the vitreous, a high degree of tension, or it may be due to the patient's fault. It must therefore be evident, as far as an escape of vitreous is concerned in a capsule-laceration, that the location of the upper limit of the incision, be it corneal (periphery) or sclero-corneal, has very little influence on the percentage. My opinion is this :—If I have decided on performing a capsule-laceration extraction and I am sure of absolute asepsis as regards the irrigator, I am *distinctly* in favour of the sclero-corneal incision with a conjunctival flap, but if I entertained the *slightest* doubts as to its sterility, I would omit the conjunctival flap, or do a peripheral corneal incision, or, better still, a peripheral corneal incision with the puncture and counter-puncture located in the sclero-corneal region, extract as much lens debris as I could, and leave the rest for the aqueous to absorb. If the cornea was abnormally small, or the conjunctiva in a chronically inflamed condition, or the lids were granular, I would do a sclerotic incision located ·5 mm. to 1 mm. from the corneal periphery. In restless patients or those suffering with asthma, bronchitis, insanity, or anæmia, if an operation were insisted on, I would NEVER do a purely corneal incision but would advice a scleral or a sclero-corneal one with a long conjunctival flap.

The various incisions having been discussed, it now remains to make a few remarks on the toilette of the wound and the after-treatment, because it does not matter how correctly the incision has been selected and executed, for all the advantages expected with regard to the complications, difficulties and sequelæ will be lost, unless the edges of the wound be thoroughly cleared of any foreign structures before the dressings are put on. There are many ways of cleaning the edges of the incision, and, given a sterile irrigator, nothing can be more effective.

Should the iris prolapse it must be replaced either by means of the irrigator playing on it or the spatula. If it refuses, the offending area had better be excised. Clearing the edges of capsular tags should receive "SPECIAL" attention. They can be replaced in the anterior chamber by the irrigator or spatula, or if caught they should be extracted. Some surgeons, as Swanzy, play a pair of iris forceps over the entire extent of the incision and extract any capsule caught. If a conjunctival flap has been cut out it should be replaced properly, clots of blood and other foreign bodies such as cotton wool, fibres, cilia, &c., should be removed with a pair of forceps. In fact no matter how clean and normal your incision may appear to be, you should NEVER take out the speculum or the retractor until you have thoroughly satisfied yourself that nothing intervenes between the edges. There are however occasions when you cannot attempt any toilette of the incision, for instance, with a large escape of vitreous the iris is often prolapsed and any attempt at replacing it only leads to a still further escape. The best thing to do is to bandage up the eye as quickly as possible and trust to the iris receding into the anterior chamber of its own accord aided with a drop of eserine, which it generally does, for it is infinitely better to have a prolapsed iris which can be subsequently excised and treated, than to empty out the entire vitreous with a certain loss of the eye.

Before applying the bandage a sufficient quantity of cotton wool should be applied so as to fill up the hollows, &c.; this acts as a sort of an outside splint, and is especially needed in very sunken eyes. In intra capsular extraction I never take off the bandage till the FOURTH day after the operation, unless the patient complains of pain in some excess of what is expected for 5 or 6 hours after extraction. This I do because (1) There appears to be no reason why one should be in such a hurry to see the immediate result of his operation ; moreover, in operations performed on other parts of the body we do not examine the wound the day after, when healing by first intention is aimed at, unless there are evident signs of septic trouble, &c. (2) So long as the patient does not complain of pain (I exclude the complaints often made by our patients of "Itching" or "Smarting") it is an indicator that "All's well." (3) The corneal part of the incision I advocate, not being very rapid in its healing, it requires rest. (4) Iris prolapse being comparatively rare in this incision, the surgeon's attention on this point is rarely if ever required the day after the. extraction. (I always insert a drop of eserine after operation.) (5) Moreover. it is my opinion that we very often convert a normally healing incision, particularly a corneal one, into an abnormal one by changing the dressings, opening the eyelids, and washing the parts too soon after the operation and before even a moderately firm union has been established. In support of this I would remark that formerly I always opened and examined the eye the day after extraction (as we are advised to do and should do if the capsule has been lacerated) and it was the exception to get a wound that had healed normally. Most of the incisions were irregularly united and some delay was experienced. In fact I often observed that a wound, which was apparently uniting normally on the first day, presented a "TOTALLY" different appearance on the next day ; sometimes I noticed that the corneal part of the incision burst open at the time of the first dressing (*i.e.*, the day after extraction); this is no doubt due to either a sudden spasm of the eyelids, a movement of the head, the eye resenting being handled or to a little roughness on the part of the surgeon. Now that I have given up this practice and open the eye on the 4th day, my experience is just the OPPOSITE, most of the incisions are found to be firmly and normally healed.

In capsule-laceration extraction, on the other hand, I always open the eye the day after operation, because (1) The incision having been made in a vascular tissue, union is not only more rapid but firmer (almost completed in 24 hours) and it is able to stand an examination without much fear of reopening. (2) Iris incarceration being a more frequent complication, the prolapsed tissue can be better attended to and treated the day after the operation than if you waited for 3 or 4 days, when it would be found to be firmly anchored in its new position and its replacement would be not only undesirable but impracticable.

A few "Don'ts" will not, I think, be out of place and may be of some value to those who have just started operating on cataract :—

(1) "Don't" be afraid to make a large incision, especially if you have selected a purely corneal one ; beginners are apt to suffer from this. It is less harmful to make too large than too small an incision. I refer to its diameter chiefly.

(2) "Don't" enter the point of your knife too obliquely when executing the puncture and counter-puncture ; you are likely to push the knife between the corneal lamellæ, reduce the internal dimensions of the incision, and experience much difficulty in extracting the lens. If you find this happening, take the knife out and start your incision again, for no harm has been done as the anterior chamber has not been opened or entered.

(3) "Don't" be in a hurry to make the counter-puncture, look well where the point of your knife is entering and change its position again and again till you are quite satisfied.

(4) "Don't" press on the eye ball with the fixation forceps,—beginners often do this,—for by doing so, the lens and the iris are pushed forward, reducing the depth of the anterior chamber, and stand in danger of being bruised or cut during the upward execution of the incision and the operation is made a painful one.

(5) "Don't" use any but a very sharp cataract knife; with a blunt knife more force is required to execute the incision, the edges of which are not cleanly cut, but are bruised.

(6) "Don't" use a knife with a long thin point, as so often happens to a Von Graefe's knife after repeated setting; the blade is much weakened, and on attempting the counter puncture it is liable to break (as happened once with me). Even if it does not break, it often bends in such a manner as to prevent a proper counter-puncture being effected.

(7) "Don't" grasp the knife in too cramped an attitude; it should be held lightly, and in such a manner that the operator has absolute control over the blade.

(8) "Don't" delay or alter the direction of the blade when once the puncture and counter-puncture have been completed, except to get the edge out of the way of any projecting iris. If you do, aqueous escapes, the anterior chamber is shallowed, and the iris is likely to be considerably bruised.

(9) "Don't" be afraid to use the left hand for a left eye operation, and say "Oh I'll use my right hand this time." The desire will be sure to repeat itself again and again and, if you give in, your left hand will be practically useless, and personally I cannot imagine an eye surgeon who is unable to use his left hand well. You will no doubt have some peculiar experiences at first, and your incisions will be situated any where but where they were intended to be; in time you will be glad you persevered.

(10) "Don't" take your eyes off the cutting edge of the knife from the start to the finish of the incision.

(11) "Don't" execute the incision with a number of short jerking to and fro movements of the knife. An incision so made is sure to be not only unevenly cut, but the edges are bruised, aud this does not favour normal healing. After the counter-puncture is made push on the blade of your knife till the centre of it lies in the anterior chamber, with equal parts on either side of it; with the knife in this position two or three movements are sufficient to complete the incision. (Sweeping movements are only intended for the gallery.)

(12) "Don't" be in a hurry to finish the summit of the incision, there should be no jerking at this stage, it should be most leisurely accomplished, the cutting edge of the knife should be turned somewhat obliquely, and when almost out, it should be turned directly forwards: this gives to the incision a valvular character.

(13) "Don't" allow any part of the blade that has once touched the lid margin to enter the corneal wound: this is very likely to happen, and to guard against it I always cut the eye-lashes of both lids quite short. This gives the knife more freedom; moreover, it is much easier to sterilise a lid margin with the eye-lashes cut quite short than one not so treated.

(14) "Don't" be afraid of any iris tissue that might happen to come in the way of the knife; try, of course, to get free from it, but donot do so at the sacrifice of an escape of aqueous with a resulting shallow anterior chamber, for this will not only increase your difficulty, but what should have been a painless operation is converted into an acutely painful one. If you find that the iris persists in coming in the way, and the operation cannot be postponed, then just let your knife "rip" and cut its way through the iris. It is much better to do this, with a resulting irregular coloboma, than to alter the direction of the blade and empty out the anterior chamber, which means that as you proceed with the incision the entire upper half of the iris is seriously injured, or a coloboma at a most undesirable place is cut out.

(15) "Don't" start the incision until you are sure, by a pull or two on the fixation forceps, that the conjunctiva will not overlap the point of the knife on the nasal side of the incision. This often happens, and can be avoided by slackening or tightening your hold on the conjunctiva, or by slightly altering the position of the forceps.

(16) "Don't" forget to see that the eye is thoroughly cocanised before the incision is commenced; this advice is mostly needed when one has a number of extractions to perform at one sitting.

(17) "Don't" get nervous if you find that you have introduced the knife with its cutting edge pointing downwards, the operation can be postponed, or the mistake can be easily rectified by turning the knife on its longitudinal axis at an angle of 180 degrees and continuing the incision as if nothing untoward had happened.

(18) "Don't" do a purely corneal incision in patients suffering with anæmia, asthma, chronic bronchitis or in a restless patient.

(19) "Don't" forget that the nearer the incision is to the periphery of the cornea and sclera the more frequently does iris prolapse and the higher is the percentage of vitreous escape, and *vice versa*.

(20) "Don't" make the incision too far into the sclerotic, lest you cut across important structures situated here and encroach on the dangerous zone.

(21) "Don't" forget to give your most careful attention to the toilette of the incision, replacing the conjunctival flap should one have been cut.

(22) "Don't" forget that the blade of a Von Graefe's knife is roughly 2 mm. broad: this measurement can be made use of should you be in any doubt about the distances permissible.

(23) "Don't" try and force the lens out of too small an opening; if you do, and you are performing an Intracapsular extraction, the capsule is sure to burst and an escape of vitreous, maybe before the lens is out, is likely to occur. If you are doing a capsule-laceration operation, the edges of the incision are bruised and healing is irregular and delayed; moreover, much of the cortical matter which would easily have accompanied the lens, if the incision was made large enough, is left behind to cause its train of symptoms, especially iritis. When you find that the incision is too small (and this is likely to be the experience of the best eye surgeons) cease from any further attempts at extracting the lens and enlargen the opening with a pair of scissors—a knife will not do so, scissors possessing a curvature concentric to that of the cornea are the most suitable.

(24) "Don't" forget that cocaine, beside its deleterious effect upon the corneal cells, with diminished Karyokinesis, has a softening or soddening action on the epithelial layer of the cornea and therefore no instruments should touch any part of the cornea when it is *quite* dry (as so often happens should the operation be a prolonged one), lest we cause an abrasion. It should be continually moistened with a lotion.

(25) "Don't" forget that the average width of a lens is 9 mm. and its thickness 5 mm. and that your incision should be proportionately sized.

(26) "Don't" forget that liquid and soft cataracts can, by moulding themselves, be extracted through an incision whose diameter is less than that of the lens.

(27) "Don't" forget that a hypermature cataract consists mainly of a hard nucleus with little or no soft matter and that the nucleus, though not as thick as a soft cataract, yet being large in diameter and unmouldable, requires an incision with a large sized base.

In conclusion, I do not ask that my statements and opinions be accepted as dogmas. I offer them for what they are worth, based as they are on the observation and experience of the writer, of a few thousand cataract operations, and an ophthalmic experience of nearly 15 years. I would ask my readers to carefully observe and study each case before operating on it, let them select their incisions according to the requirements of the case, and, after the operation has been performed, let them minutely watch the progress of the case, say, for 14 days afterwards, and note the influence of these various incisions on the manner of healing, the acuity of vision, the degree of astigmatism, and the other complications and sequelæ usually experienced in a cataract operation, and then let them put themselves this ONE question,—"COULD I HAVE GONE 'ONE' BETTER"? I am sure that in the end we shall find that we do not disagree on many points, and I shall feel that this subject, though it embraces many elementary points of practical ophthalmology familiar to most of my readers, has not been written without some slight benefit.

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DISCUSSION.

Major Smith did not agree with Capt. Gidney in saying that escape of vitreous depends on the nature of the incision.

STONE IN THE BLADDER WITH NOTES ON LITHOLAPAXY, PERINŒAL LITHOTRITY AND LITHOTOMY.

BY LIEUT.-COLONEL P. DURRELL PANK, I.M.S.

The following remarks refer to a series of 416 operations for vesical stone performed at the Mayo Hospital, Jaipur, and extending over a period of eight years: of these operations—

383 were done by Litholapaxy with 10 deaths or a mortality of 2·6 per cent.
11 „ „ „ Perinœal Lithotrity with no deaths.
19 „ „ „ Lateral Lithotomy with 3 deaths or a mortality of 15·7 per cent.
3 „ „ „ Suprapubic Lithotomy with one death or a mortality of 33·3 per cent.

The following is briefly the operative method pursued at the above hospital in cases of vesical stone:—

The presence of stone in the bladder is first settled, before admission to the wards, in the ordinary way by using a suitable sound, and, as a general rule, without chloroform, which however should be used in some children with irritable bladders, in cases of enlarged prostates, or where the stone cannot be found without the aid of an anæsthetic; in addition to the sound in the bladder, the right index finger of the surgeon pushed as far as it will go into the rectum and hooked up well under the symphysis pubis will, aided by the beak of the sound, often find a stone, especially in children, which had previously escaped detection: failing the above methods of diagnosis, a small quantity of fluid injected into the bladder and the careful use of a canula and evacuator should be tried and it is very seldom that a stone or fragment, however small, will under this plan escape detection.

The presence of the stone having been demonstrated, the patient, if he cannot or will not wait for preparation, is operated on at once, and as far as my experience goes I am led to believe that there is no serious objection to this immediate operation which is done in a large number of cases at the Mayo Hospital; if he be in no great hurry he is kept in bed for two or three days, put on light diet, has a warm bath daily, is given alkalies or urotropine if cystitis be present, and on the evening before the operation gets a dose of castor oil and an enema early the following morning.

The height of the operation table is a very important matter and should be regulated so that the surgeon does not have to stoop and is such that he will be the least easily tired or inconvenienced: the patient is fully extended, his legs are not raised and the surgeon stands on his right side; in addition to the essential instruments for performing litholapaxy I use the following:—

A narrow tin dish, placed between the patient's thighs to catch fluid and fragments of stone falling from the canula; a glass douche attached to the wall 4 feet above the operation table holding about four pints and graduated by marks to show quantities of two and a half ounces,

and furnished with a half inch rubber tube ending in a sharp-pointed rubber stop cock suitable for insertion into any canula; this douche is kept filled with warm sterilized boric solution; a small china basin for the fragments of stone; a pail full of warm sterilized water for the instruments; a small thin soft towel which is often required to be used on the handle of the lithotrite to protect the surgeon's hands; and a quantity of sterilized soft soap, best placed on the back of the surgeon's left hand, to be used in addition to lubricating oil.

All being ready and the patient fully under chloroform the operation is briefly performed as follows:—

The surgeon standing on the right of the patient, the urine is drawn off, and, by means of the raised douche, about five or six ounces of warm boric lotion in the case of an adult and less for a child is injected into the bladder; the lithotrite, well oiled and soaped, is gently introduced into the bladder and opened with the convexity of the jaws looking upwards (not downwards as some text books teach; the unlocked lithotrite is gently opened and closed in various positions and directions, the jaws being gently pressed into the floor of the bladder until the stone is caught, it is then locked, and with the stone is brought to the centre of the base of the bladder, the instrument is gently rotated and if found perfectly free, two or three half turns are given to the wheel or handle until the stone is felt or heard to break: this happens easily and quickly in many cases, but there are stones, such as oxalates, and a reddish brown stone, common in patients in Rajputana, which are of a very fine grain and intensely hard and tough: these should be dealt with very deliberately and carefully and the intervals between the separate turns of the screw should be long, fully half to one minute; in many cases this plan will result in a sudden loud fracture to be heard all over the operation room; but, if after carefully applied pressure the stone does not yield, the lithotrite should be opened and the stone dropped and recaught in a fresh grip and the same procedure followed and repeated until the stone breaks, that is, if it can be broken, for some stones, and they are fortunately few, cannot be safely broken by any instrument passed through the urethra and must be dealt with otherwise.

It will be wise for the operator to remember that cases are on record in which the stone is so hard, and it may be that the temper or strength of the lithotrite is defective, that when the screw is being slowly but forcibly tightened up, the stone is not breaking but the jaws of the instrument are bending; this is a most formidable accident, and can only be met by a suprapubic or median perineal incision and removal of the bent portion by means of a file; to attempt to withdraw the lithotrite through the urethra would be fatal: a finger in the rectum will help to diagnose the actual state of affairs: this accident once occurred to me in my hospital practice.

The fragments of the broken stone are then dealt with in a similar manner until the stone or part of it is reduced to fragments small enough to pass through the canula by means of the evacuator.

An experienced surgeon need not lock his lithotrite on every individual fragment for it is just as safe and far quicker and easier in experienced hands to use the unlocked instrument and break up soft fragments by means of the hands alone; I use this method constantly and have never seen any harm come from it; I find it results in a great saving of time which is of considerable advantage to the patient; it is not necessary to reduce the stone to fine powder, in fact it is undesirable to do so as a powdered stone is more difficult to completely wash out of the bladder than a stone in fragments small enough to pass through the canula: when the last fragment is washed out of the bladder the operation is ended: the patient is kept warm and, if necessary, his lower abdomen is fomented; in cases of severe cystitis, or irritable bladder symptoms, urotropine is given for a few days. It is very necessary that the anæsthetist should be a capable and experienced man so that the surgeon need not constantly watch the effect of the chloroform but can devote all his attention to the operation without distraction.

Many cases of litholapaxy are very easy of performance and when done by an expert do not entail more trouble or risk than a minor operation; the operation on the other hand may be protracted and difficult and may severely tax the surgeon's strength, skill and endurance.

I am a fairly quick operator and appreciate the great advantage of any saving of time in these operations, but I have been kept hard at it for two hours over a litholapaxy and have had my hands bruised and blistered and felt the results of the operation for days: a good way to meet this severe call on endurance and skill is to have a table of proper height and to use a small thin towel to protect the hands.

The following remarks are the result of my experience in litholapaxy:—

The surgeon should be very careful not to use any lithotrite or canula which does not traverse the urethral canal fairly easily and never to use force when passing or withdrawing any instrument: more soap or oil or a smaller instrument will ensure easy passage of the instrument.

Some bladders will tolerate or hold very little or no fluid, or resist the injection so strongly as to reject what is introduced with such force as to perceptibly raise the column of water in the tube and in the douche hanging four feet above the operation table; the best way to meet this is to give more chloroform and increase the state of anæsthesia.

In an operation of some duration and sometimes after a few minutes use of the instruments the lithotrite or canula may work stiffly, or cling as it were to the urethral wall or require more force to introduce it, this may be due to the powdered stone acting on the blades of the lithotrite, to a congested or abraded urethra, or to comparative dryness of the latter, and the obvious

remedy is more oil and soap and greater gentleness or a smaller instrument.

Bleeding may occur during or after litholapaxy from an irritable inflamed bladder, an enlarged prostate, when the meatus is narrow and intentionally cut, or from injury to the wall of the urethra from the instruments or fragments of stone in the eye of the canula.

The operation may be rendered difficult from the following causes :—

1. A large stone, which no lithotrite capable of being safely passed by the urethra can grasp ; this is best met by perinæal litholapaxy, perinæal lithotrity, or lateral lithotomy : some large soft stones can be crushed by first nibbling at them till they are sufficiently reduced in size or enable the lithotrite to thoroughly grip and crush them.

2. A hard stone—there are some black or yellowish brown stones, not too big but too hard to be crushed by an ordinary lithotrite ; they should be crushed by perinæal litholapaxy or lithotrity.

3. Stricture of the urethra—treat the stricture by dilation or operation and then do an ordinary litholapaxy or a perinæal litholapaxy or lithotrity behind the stricture.

4. A very irritable bladder—the best thing to do is to increase the anæsthesia and operate in the ordinary way.

5. An enlarged prostate—this may only mean a longer operation with increased gentleness and care, or a suprapubic lithotomy with removal of prostate by Freyer's operation.

6. A depression behind prostate—an assistant's finger in the rectum raising the floor of the bladder will often meet this difficulty.

7. In my experience sacculated bladders with encysted stones are very rare and are more often met with by young and eager surgeons than by older and more experienced men.

8. A stone may lie partly in the neck of the bladder and partly in the urethra and if it cannot be gently pushed right back into the bladder by manipulation or by the lithotrite the best operation is a lateral lithotomy.

I would say that about 95 per cent. of all stone cases can be successfully treated by urethral litholapaxy and that the usual cause of death after this operation is, if the operation has been properly done, mostly due to kidney disease which is by no means rare in children or adults who have suffered for some time from vesical stone.

In regard to instruments I prefer a Thompson's or Freyer's lithotrite : the former fitted with an inverted V shaped projection for locking the instrument ; this does not punish the fingers in the way that the old fashioned button-shaped projections did : I have always used a Berkley Hill's evacuator, there are doubtless better ones of a more modern type, but this evacuator has always given me every satisfaction.

Small stones in the urethra can sometimes be manipulated back into the bladder and crushed in the ordinary way, but if too big for this they may be extracted by suitable urethral forceps, and failing this should be cut down on in the middle line and extracted ; the small wound may be left to heal of itself.

The following is a very brief analysis of the series of cases referred to in this paper :—

Of the 383 cases treated by litholapaxy 150 were under 5 years of age ; 17 were two years of age ; one was one year old and one was only eleven months.

97 were over 5 and under 10 years and one was over eighty, 365 cases occurred in males, 18 in females.

Of the 383 cases 10 died, showing a mortality of 2·6 per cent : the smallest stone weighed 2 grains, the largest 2307½ grains, dry, the average stay in hospital after litholapaxy was 4·54 days.

The reported duration of the disease at the time of operation was from 8 days to 10 years.

We had a run of 130 consecutive cases of litholapaxy at the Mayo Hospital without a death and for the five years, 1897-1901, the mortality per cent. was ·45 only.

During the nine years to which these remarks are confined 19 cases were operated on by lateral lithotomy —of these 16 were cured and 3 died—mortality per cent. 15·7—the largest stone weighed when dry 5 ounces.

Eleven cases were operated on by Perineal Lithotrity with no deaths, largest stone, dry, 10¼ ounces ; this case made a good recovery.

By suprapubic lithotomy three cases were operated on, two recovered and one died—mortality per cent. 33·3, largest stone weighed 7½ ounces.

I have no exact knowledge of the cause of stone, but it is I think a remarkable fact that all the above 416 cases occurred in what were practically poor people and during these nine years I met with only two cases in well-to-do people—one was a boy of 10, and the other an adult male ; it is also remarkable that, out of the 416 cases, 250 were in children of ten years and under.

I very much regret that I have no statistics available or remarks of any use to make on the important subject of recurrence of stone after operation.

In regard to the choice of operation, in my opinion, litholapaxy has proved itself to be, in the hands of experienced surgeons, so successful, from every point of view, that there is nowadays no comparison to be made between it and any other method : next to litholapaxy I regard perineal litholapaxy to be the best operation, by this I mean a small incision into the urethra in front of the prostate, not cutting this gland or the bladder, which will admit a sufficiently large lithotrite and canula, and then if this operation were not practicable I would employ perineal lithotrity in which the prostate and neck of bladder is cut in the median line, but only to the extent of admitting a very large lithotrite. The case must be a rare one which cannot be dealt with by one of these three methods. I would employ lateral lithotomy as a last resource and suprapubic lithotomy never, for I can imagine no case in which the suprapubic operation could be more likely of success than those above mentioned : in addition to the

high mortality there is in my opinion one serious objection to the suprapubic operation which does not hold in regard to any other operation for vesical calculus in which the surgeon is driven to cut the bladder, and that is the difficulty of effecting efficient drainage after the operation which is so essential in cases of the nature in question especially when cystitis with septic putrid urine or a state of intense bladder irritability may co-exist.

416 cases of vesical calculus were operated on at the Mayo Hospital, Jaipur-Rajputana, during the nine years 1899-1907. The following gives briefly some information and the statistics of these cases :—

By Litholapaxy.—

Total cases operated on	383
Cured	372
Died	10
* Otherwise	1

Mortality per cent., 2·6.

Of the above

309 were Hindus.
73 ,, Mussulmans.
1 was a Christian.

Age at time of operation.

150 were 5 years of age and under	365 males. 18 females.
97 ,, from 5 to 10 years.	
38 ,, ,, 10 ,, 20 ,,	
25 ,, ,, 20 ,, 30 ,,	
21 ,, ,, 30 ,, 40 ,,	
32 ,, ,, 40 ,, 50 ,,	
16 ,, ,, 50 ,, 60 ,,	
3 ,, ,, 60 ,, 80 ,,	

1 was above 80.
17 boys were 2 years of age.
1 boy was 1 year ,, ,,
1 boy was eleven months of age.

Reputed duration of disease from 8 days to 10 years.

Smallest stone weighed 2 grains.

Largest ,, ,, 2307½ (5oz. 122 grains).

* The case "otherwise" was removed from the Hospital 10 days after operation by his friends.

Crushing average 11·21 minutes.

Washing out average 9·83 minutes.

Crushing varied from 1 minute (stone of 2 grains) to 59 minutes (stone of 1080 grains).

Washing varied from 1 minute (stone of 2 grains) to 50 minutes (stone of 611 grains).

Time taken in entire operation varied from 2 minutes to 2 hours.

Number of Lithotrite.	Number of Canula.
No. 5 was used 86 times	No. 5 was used 21 times.
6 ,, ,, 64 ,,	6 ,, ,, 33 ,,
8 ,, ,, 95 ,,	7 ,, ,, 41 ,,
10 ,, ,, 48 ,,	8 ,, ,, 94 ,,
12 ,, ,, 113 ,,	9 ,, ,, 16 ,,
C ,, ,, 4 ,,	10 ,, ,, 54 ,,
A ,, ,, 14 ,,	12 ,, ,, 23 ,,
	13 ,, ,, 8 ,,
	14 ,, ,, 19 ,,
	15 ,, ,, 31 ,,
	16 ,, ,, 21 ,,
	17 ,, ,, 4 ,,
	18 ,, ,, 18 ,,

Average stay in Hospital, 4·54 days.

Composition of Stones.—

Oxalate and phosphate	124
Oxalate and urate	38
Oxalate, phosphate and urate ...	30
Phosphate and urate...	25
Phosphate	47
Urate	79
Oxalate	38

By Lateral Lithotomy.—

Total cases operated on 19—cured 16, died 3. Mortality per cent 15·7. Largest stone weighed when dry 5 ounces.

By Perineal Lithotrity.—

Total cases operated on 11—cured 11, died 0. Largest stone weighed when dry 10¼ ounces.

By Suprapubic Lithotomy.

Total cases operated on 3—cured 2, died 1. Mortality per cent., 33·3. Largest stone weighed 7½ ounces.

A NOTE ON
LITHOLAPAXY IN INDIA.

By D. F. KEEGAN, F.R.C.S., I.M.S. (RETIRED).

Mr. President,

My first duty is to thank the Central Representative Committee of the Bombay Medical Congress for the honour they have done me in inviting me to read or to contribute a paper on Tropical Surgery. There are but two subjects in Tropical Surgery upon which I can write with any authority, *viz.*, the fashioning or repairing of new noses, and the treatment of vesical calculi and I select the latter as being incomparably the more important of the two. In the presence of so many past masters in the craft of crushing vesical calculi, it would almost amount to an impertinence on my part if I were to dwell

on the advantages which litholapaxy possesses over all its rivals in dealing with the great majority of cases of stone in the bladder in young and old patients of both sexes. And if I had not noted a tendency of late years, in some portions of India to substitute a cutting for a crushing operation, and in other parts of India a decided disinclination to adopt litholapaxy, I do not think I should have felt justified in writing a paper for the consideration of the surgical section.

There is hardly anything new to be said or written on litholapaxy, for the subject is almost threadbare and the operation has now for some years been established in India on what I would fain hope is a sure and lasting basis. Regarding the technique of the operation, the only suggestion I would offer is that when litholapaxy is performed on boys, the evacuating canulæ employed should be made a little shorter than they used to be some years ago, and that the exhausting bags should be of smaller capacity than those usually used in the operation on adult males. And I may add that all evacuating canulæ employed in the operation both for boys and adults should be fitted with steel stylets. It is now more than 30 years since the great Bigelow substituted litholapaxy for its halting prototype, lithotrity of many sittings, and during this long period, 165,000 cases of stone in the bladder have been submitted to operation in India, for every year in India we deal in round numbers with 5,500 vesical calculi. Put in this way, we can readily realize the vast amount of suffering entailed on the Natives of this country by stone in the bladder, and therefore anything bearing on this subject must always have a supreme interest for the practical surgeon whose lot is cast in a calculous district in India.

Litholapaxy being unquestionably the best operation or the vast majority of cases of vesical stone in old and young patients of both sexes, what is the best operation to adopt in those cases in which it is not feasible by reason either of the great size or excessive hardness of a stone ?

Personally, I lean to the opinion that the answer to this question will be found in some form of perineal lithotrity, and not in suprapubic lithotomy. In the *Indian Medical Gazette* for January 1901, I pleaded for the efficient registration of all operations for stone in the bladder in India in order to solve this problem ; but I pleaded in vain, and we are to-day as far off as we were then from a satisfactory solution of the problem. I appeal once again, and I ask the Director-General of the Indian Medical Department to kindly issue instructions that all cases of stone in the bladder in India should be tabulated for the next two or three years according to age, sex, caste, duration of disease, date of operation, time in hospital after operation, weight and composition of stone, nature of operation, and result. We should then have absolutely trustworthy data regarding something like 15,000 cases of stone in the bladder, and the problem would be readily solved, and with its solution many valuable lessons in the treatment of stone in the bladder would be learned.

And now in conclusion I should like to touch very lightly on a subject of great practical importance regarding the future of litholapaxy in India.

The young and inexperienced Surgeon of the Indian Medical Service on landing in this country is, as a general rule, posted for some few years to the medical charge of a Native Regiment, and having a bent for surgery in course of time, selects Civil employment. He is posted to a Civil Hospital in a calculous district, and is at once brought face to face with patients suffering from stone in the bladder. How is he to treat such patients ? He can wield a scalpel dexterously ; but unfortunately has no practical familiarity with the use of the lithotrite, and during the six or seven years he has been studying Medicine and Surgery may have never enjoyed an opportunity of seeing a stone in the bladder crushed by an expert. For we all know that even on the staffs of all the large hospitals in London put together, there are very few surgeons who can crush a stone in the bladder with precision and dexterity. And the young surgeon may never have attended at a hospital specially devoted to urinary diseases. He is therefore inclined to do a cutting operation, be it a suprapubic or a lateral lithotomy, instead of a crushing operation, and if at starting, he achieves a fair success in lithotomy he may never during the rest of his career in India take kindly to litholapaxy and as a result his patients are bound to suffer in the long run. What is the remedy for this state of things ? It is a very simple one indeed. Prior to his being definitely posted to the calculous district, the Inspector-General of Civil Hospitals under whom he is about to serve should send him for a couple of months to receive practical instruction in litholapaxy at the hands of a past master in the craft of crushing calculi. If his lines are cast in the Bombay Presidency he should for choice be sent to Hyderabad Sind where he would learn more practical knowledge regarding litholapaxy in a few months than in a year spent elsewhere. If he is to serve in the Punjab, a few months spent at the Civil Hospitals of Mooltan, Jullundhur or Lahore will teach him much and give him confidence. And now, Mr. President, I beg to thank you once again for the honour conferred on me.

THE TREATMENT OF STONE IN THE BLADDER.

By Major H. SMITH, I.M.S.,

Civil Surgeon, Jullundur.

The treatment of stone in the bladder in India will always continue to be of great importance to both the surgeon and to the people on account of its prevalence. As regards this subject we may safely set aside the views of European and American surgeons as of little importance. Their experience is so limited that their opinions on the rival operations may safely be treated by Indian surgeons as hardly worthy of consideration. This is a matter we have got to settle for ourselves independent of the outside world and to settle for it too. The following statistics may be taken as fairly representative of the rival operations in India:—

The stones of the Punjab, United Provinces, and Bombay Presidency for the years 1890-95—

Litholapaxies ...	10,073	Death-rate	3·96 %
Lateral Lithotomies ...	7,201	,,	11·02 %
Suprapubic Lithotomies.	147	,,	42·17 %

The stones of the United Provinces in 1907—

Litholapaxies ...	670	Death-rate	5·03 %
Lateral Lithotomies ...	321	,,	13·4 %
Median Lithotomies ...	43	,,	9·3 %
Vaginal Lithotomies ...	5	,,	20·0 %
Lithotrities ...	31	,,	29·0 %
Dilatation of the Female Urethra ...	13	,,	0·0 %
Suprapubic Lithotomies.	44	,,	20·0 %

The stones of the Punjab in 1907—

Litholapaxies ...	2,051	Death-rate	4·5 %
Lateral Lithotomies ...	185	,,	11·8 %
Median Perineal Lithotomies ...	12	,,	0·0 %
Vaginal Lithotomy ...	14	,,	7·1 %
Lithotrities ...	8	,,	0·0 %
Perineal Lithotritries ...	15	,,	0·0 %
Dilatation of the Female Urethra ...	43	,,	0·0 %
Suprapubic Lithotomies.	50	,,	20·0 %

Under the Stones of the Punjab and United Provinces for 1907, I include those discharged from the hospital as "relieved," "discharged otherwise," and "died" as all having died, as in my observation the two former classes are taken away by their friends in a moribund condition. The people have an objection to their relatives dying in Hospital.

It will thus be seen that, excluding the cases of dilatation of the female urethra, in the United Provinces in 1907 37 per cent. of the remaining stones were submitted to a cutting operation, and in the Punjab in the same year 11·2 per cent. of the remainder were submitted to a cutting operation. It will also be seen that 1·5 per cent. of all cases were dealt with by dilatation of the female urethra, which implies that at least half the cases of stone in females were dealt with in this way, as the incidence of stone in women falls somewhat short of 3 per cent. of the total stones in both sexes.

Keith's Operation or Perineal Litholapaxy.—Colonel Keith publishes 159 cases with a death-rate of 1·88 per cent.

Colonel Henderson publishes 110 cases with a death-rate of 2·73 per cent.

Major Baker publishes 253 cases with a death-rate of 1·97 per cent.

These figures united give 522 cases with a death-rate of 2·1 per cent.

The prevalence of lithotomy in the United Provinces seems to me to require some explanation. My opinion is that it is not the fault of the surgeons. From figures published a few years ago concerning the equipment of hospitals for litholapaxy it was plain that there was not more money spent on equipment for the treatment of stone in those Provinces than would properly equip 20 per cent. of the district headquarters hospitals and hence recourse has to be had to lithotomy in some form.

Urethral and Perineal (Keith's) Litholapaxy.—In the figures above quoted litholapaxies stand out so prominently that no surgeon can hesitate to come to the conclusion that they are the operations of election in nearly all cases; the few exceptions I shall point out later on. The fact that certain hospitals are not properly equipped is no argument as concerns the merits of these operations. The figures above quoted are strong arguments why the hospitals should be properly equipped as soon as possible and that the officers in charge should persistently press those who hold the purse strings to pay for the necessary equipment. Dilatation of the female urethra for the removal of stone is in my opinion a barbarous operation. It is certain to be followed by permanent incontinence of urine in the great majority of cases and I have little doubt that the woman who has thus been treated for stone will remember the operator while she lives and that her comments on him will not be of a very friendly nature. These cases are amenable to litholapaxy if the operator's assistant inserts his finger into the vagina or rectum and keeps it pressed against the urethra so as to keep the necessary amount of fluid in the bladder. If lithotomy has to be done on female subjects the vaginal route is much the best.

Suprapubic Lithotomy.—Why this operation holds even as prominent a position as it does in India it is difficult to say.

The appalling death-rate above shown should be enough to condemn it for ever. My experience of suprapubic cystotomy is limited to the removal of enlarged

prostates and so dissatisfied am I with it that I have given it up and have adopted the perineal route for removal of enlarged prostate as advocated by Young of Baltimore. It may have a much smaller death-rate in Europe and America than is associated with it in India. But this is due to the fact that in Europe and America nursing arrangements leave little to be desired, whereas with us in India nursing arrangements are of the most primitive nature. In any case the patient has to remain an average of six weeks in hospital, and when done, his bladder is fixed to a dense scar in a position in which nature never intended it to be fixed and on this fixed scar calcareous deposit is very liable to form and constitute the nucleus for another stone. It has the advantage, if the patient lives, of not running any risk of injuring the seminal ducts. With regard to suprapubic lithotomy in the above figures there is no information at my disposal to show that this route was adopted for bad cases only. My impression is that such was not the case, but that in most cases it was the operation of election by junior surgeons who had seen it done in Europe and that as time wears on these men give it up from sad experience and adopt litholapaxy or the perineal route instead.

Median Lithotomy is an operation which does not give enough room and an operation which is certain to injure the seminal ducts, and hence in my opinion it should cease to be practised.

Lateral Lithotomy is the safest of the cutting operations. It is one of the simplest operations in surgery and at the same time one of the easiest to bungle. The bladder should be distended with fluid.

The staff should be inserted well into the bladder and not taken out until the finger enters the bladder through the wound. The Assistant should lift it against the pubic arch. The operator should pass his index finger into the rectum, and feel for the groove through the tissues of the perineum with the nail of the thumb of the same hand, and pass in a long bladed sharp knife alongside his thumb nail until it has entered the groove and pass it on until it is well into the bladder. He should then elevate the proximal end of the blade and depress the point and with a draw cut make the necessary opening in the bladder and prostate. He should then elevate the point and depress the proximal end of the knife and with a draw cut finish the incision in the skin. The finger of his left hand in the rectum should draw it away from the knife while he is cutting. The utmost care should be taken throughout that the incision is really lateral so as to avoid injuring the seminal ducts. If the incision be done in this way there is no danger of wounding the rectum—a serious accident and a much commoner one than most Surgeons think, though there are no statistics bearing on it.

Lithotomy forceps should be made much stouter than they at present are, once you get hold of a stone in forceps it is extremely difficult to get it out of the grip if desired and hence we have got to fetch it out. For this reason the instrument should be made so stout that it will not spring when submitted to the full pressure of a pair of strong hands. This can be done without increasing its dimensions as evidenced by the lithotrity forceps here shown—a forcep, which as you can see, is capable of crushing small stones or fragments and of trimming off the parts of fragments which may project over the blades. It was for this latter purpose I got it made and it does its duty efficiently.

Perineal Lithotrity.—This operation was devised to deal with large or hard stones through a lateral perineal wound. Instruments were formerly used which would take as large a wound to let them in as would let out the whole stone, such as the one handed round. As the procedure is intended to remove the stone through an ordinary sized wound such instruments were absurd. I think it is generally admitted that the death-rate in large stones is proportional to the size of the wound. The No. 26 lithotrite shown I ordered for that purpose, but I found it very difficult to harness on the stone in the empty bladder and the cutting forceps shown I got made for the purpose. It is easily harnessed on the stone and is efficient to put one or two cuts in a large stone after which the fragments can be crushed up and taken out with the forceps with the margins of the jaws serrated—the serration was intended to trim the projecting angles of the fragments and to crush them up, which it efficiently does. Such projecting margins tear the prostate if drawn out with ordinary forceps. These instruments Weiss now makes.

We hear it still advocated that stone is more likely to recur after litholapaxy than after lithotomy as an argument in favour of the latter operation. Let us take the litholapaxies of the Punjab and United Provinces in the year 1907; we find that in the Punjab, there were nine secondary operations for fragments left behind in a total of 2,051 cases, and in the United Provinces 3 in 670. A fragment of stone left behind sharp as it always is, is certain to be complained of immediately and to be dealt with before the patient leaves Hospital. These figures I think should settle the question. Of course, no one assumes that if the stone is completely removed the patient is more likely to have another after litholapaxy than after lithotomy, but the reverse does not hold good. Litholapaxy does not leave any scars in the bladder which would cause substances in solution to deposit on them. The reverse of this holds good with any form of lithotomy. I have frequently seen cases in which such deposits occurred after lithotomy, producing a stone either in the bladder or in the wound, and in the latter case I have seen a number of cases of permanent fistulae caused by such stone or deposit. The facts are all against those who say that stone is more likely to recur after litholapaxy than after lithotomy owing to the fragments left behind in the former operation. A competent operator seldom leaves fragments behind after litholapaxy; assuming that Hospitals are properly equipped with good lithotrites from No. 4½ to No 18 English scale, few stones will be met which cannot be dealt with by urethral litholapaxy, and if a No. 20 be added very few indeed will be met which cannot be dealt with by urethral and perineal litholapaxy at any age. No arguments will stand against the statistcis

quoted above in favour of these operations. Operations which admit of the patient leaving Hospital 24 hours after operation; whereas lateral lithotomy detains him 21 days and suprapubic lithotomy detains him an average of six weeks in Hospital. The argument is still advanced against these operations that the average general surgeon cannot do them, from want of experience. This is quite true and if he operates I have no doubt lithotomy in some form will be safer in his hand, but surely this is a lame excuse—surely a last refuge. The general surgeon does not operate on cataract but sends it to a specialist. It is equally his duty to his patient if he has no other argument and does not feel competent to do a litholapaxy to send him to a man who can do it. There are a few cases in which it will always be the operation of election to cut for stone, *e.g.*, cases of tight stricture and of severe cystitis due to the stone. I have repeatedly rued doing a litholapaxy in bad cases of stricture after dilatation and in such cases of cystitis. After dilating the stricture I advocate lateral lithotomy at the same sitting, which by draining the bladder has great influence on the stricture. Draining the bladder in this way is always advisable in severe cases of cystitis associated with stone, and the death-rate, I have no doubt, is lower in both these cases than if they were dealt with by litholapaxy. The percentage of cases requiring to be treated thus, in my experience, which now extends to about 1,500 cases of stone, ranges to about five or six per cent. Our experience of stone at Jullundur in 1908 was 125 cases with one death, which occurred in an old man with a chronically diseased bladder. About two-thirds of our cases are in children. It is no uncommon thing for us to come across children of three years of age with stone. The European Surgeon has probably a vague idea of the size of a native child of one, two or three years of age. In my observation, they are not more than half the size of European children of those ages. I did a litholapaxy a few days ago on a child one and-a-half years old, of twelve pounds weight, and it was well nourished. I once did a litholapaxy on a child of eleven months which was also twelve pounds in weight.

I would like to have the opinions of those present on:—

(1) The probability of sterility following perineal lithotomy. A universal belief among the peasantry of the Punjab is that sterility does follow this operation.

(2) On the probability of permanent incontinence of urine following the extraction of stone in females *per urethram.*

(3) The danger of over-distending the bladder by a Bigelow's apparatus whose joints or rubber is imperfect enough to admit of air being sucked in and yet not to admit of the escape of water.

DISCUSSION.

Captain Gidney—Chloroform very often helps one in detecting a stone. I would like to ask Col. Pank as to why he keeps the legs extended I think that in a child the stone must be crushed to powder, as it is difficult to wash away the fragments from a small canula which one has to use. Col. Pank mentions about nibbling at a stone when too large for the grasp of the lithotrite. What I do is to hold the lithotrite unlocked with the stone between the blades and with a small hammer tap it and so chip off the pieces and reduce the size. Can the mortality in suprapubic lithotomy be due to any permanent injury to the bladder by the stone or a bruising of the cut edges during extraction? For in suprapubic prostatectomy it is only 4—5 per cent. in Freyer's hands even though the operation is a more severe one, and age and constitution of the patient are against him. I would like to know what operation would be recommended in a stone case with enlarged prostate: Freyer's suprapubic or Proust's perineal. Suprapubic lithotomy has a very high mortality, and median and lateral lithotrity are still more dangerous and difficult. From what has been said about the suprapubic operation, I believe Proust's operation must be the one to take up. Can it be that when a stone accompanies an enlarged prostate, the stone is the result of the prostate. And if so is it not advisable to attack both of them and not only the stone, as it is very likely to reform, the cause being still there. I believe this latter would be incorrect surgery. As to the method: looking at the good results of Freyer and the rapidity and ease one would prefer the suprapubic; looking at Indian statistics the perineal would seem preferable.

It was recommended to anoint the bladder with one drachm to two drachms of olive oil after any operation on the bladder and thus soothe the mucous membrane.

Capt. Neve.—To increase the grip of the lithotrite is dangerous, because a larger stone would be attempted at, with possible danger of bending or breaking the blades. In sacculated bladder, a finger in the rectum may be a great help, as also raising up of the foot of the bed. I have devised an instrument for perineal lithotrity, which is a modification of Milton's, but having a wider angle and narrower blade, and wider turns to the screw (8 to an inch).

Major Kilkelley remarked that it is easy to burst the bladder by pumping in much air.

Major Street remarked that he had often seen it, but he believed it was due to a previously damaged bladder either from a sacculation or from instrumentation, and did not think that it was possible in a healthy bladder. As regards the handle of the lithotrite he mentioned his own device of a simple bar at right angles which is not likely to hurt the hands. Contraindication to median perineal incision is not the size but hardness of the stone. He suggested to have more turns to the screw than what was recommended by Capt. Neve, and that the depth of these be deeper that they may not wear out soon.

Dr. Wanless cited a case where though the water flowed out during the operation, a rupture of bladder was detected the next day. One must therefore be on the look out as to whether the patient passes urine all right after the operation.

Colonel Pank in reply made the following remarks.—In the case of the surgeon who meets with few cases of stone and has had small experience in dealing with them Jacobson's advice to do a lateral lithotomy is sound. In regard to Major Smith's remark regarding the danger of pumping air into the bladder, this is doubtless a very dangerous defect in some evacuators and is best met by seeing that all the joints of the evacuator are tight: calculations made at Jaipur led him to believe that the pressure from a douche as described in his paper amounted to about one and a half to two pounds on the wall of the bladder: many evacuators are extremely cumbersome and unwieldy and he highly approved of the old fashioned Berkely Hill pattern: regarding the question of what lithotrite he would use in cases of perineal lithotrity, he advised the ordinary lithotrite of a sufficiently large size: rupture of the bladder during the performance of a litholapaxy is fortunately very rare and is generally due to injury to the bladder wall by the instruments: in reply to what he would do in a case of stone complicated by enlarged prostate, Colonel Pank said he would do a suprapubic operation and at the same time remove the prostate if it necessitated removal: regarding sterility after lateral lithotomy he said the belief in this condition is very common.

Major H. Smith's reply.—As regards the danger of bursting a bladder by overdistention with air sucked in by an evacuator in bad order I have no doubt of its occurrence. I have seen a

case and did a post-mortem on it. As regards the evacuation of debris I prefer a Bigelows evacuator in good order to anything else. By filling the bladder with a syringe we cannot tell how much pressure we are putting on it as bladders containing a stone vary very much in size and it is not always the thickened contracted bladder which is the strongest but *vice versa* as such bladders are the ones in which we find thin walled sacculæ. With an evacuator we can tell definitely what pressure we are putting on the bladder as there is not the resistance of the friction of the piston to be estimated. A good deal has been said about the grip of lithotrites which would indicate that the instrument maker should give the operator more power over a given instrument. I have always found Weiss' instruments about as nearly perfect as possible. They would be difficult to improve on, and, until steel has got more power than at present, I would not advise altering from that pattern. The instrument maker is the proper person to estimate the strain his instrument is capable of bearing. True, in experienced hands, with a soft stone they would be safe with a larger grip but we have to recognise that few surgeons are mechanics and when given such an instrument many will be liable to call on it to do more than it is able thus bending it or breaking it in the bladder.

The indication that an instrument is being put to do more than it can do has not yet been touched on, and is of importance so as to avoid the bending or the breaking of the instrument in the bladder. When a lithotrite is being screwed up beyond its range of power the handle of the screw when let go springs back to some extent. When this occurs if it be pressed further it will either bend or break If not pressed beyond this point with its maximum power it will neither bend nor break. There are five lithotrites (Weiss') in my hospital in which we have been doing from 120 to 150 stones yearly for over 16 years without any repair, and they appear as good as the day they were made. Clogging of the lithotrite I have no experience of. If the bladder be kept reasonably full of water and the evacuator be used to remove debris a few times when there is enough to be an encumbrance I have no doubt it will seldom be met with. The practice advocated by some of crushing up a large stone with one insertion of the lithotrite is inconvenient and tedious and has nothing to recommend it.

Special stress has been laid on not using instruments larger than the capacity of the urethra. I have no hesitation when the urethra does not admit a large enough instrument, to stretch it with a steel sound so as to admit the next larger size and thus avoid a cutting operation. I have never had reason to rue this practice.

The President.—Clogging of the lithotrite, I believe, is due to insufficient water in the bladder, especially when the stone is soft in nature. For an impacted urethral stone I see no necessity for stitching up the urethra subsequently ; only trouble results, as the part cannot be kept clean. As regards evacuators, Thompson's, I think is the worst, being a very bulky thing, and being long in forms increasing the leverage. I prefer one where the canula fits directly to the rubber without any intervening parts. In children the evacuator opens up the great risk of rupture of bladder, and so I prefer injecting with an ear-syringe. I would wish that the terminal part of the canula were a little curved, so as to facilitate its depression for removing the last debris from the bladder. I would always give preference to lateral lithotrity or lateral lithotomy over suprapubic ; nursing in India is too poor, and the best thing therefore is to have as little after treatment and care as possible. A surgeon well up in litholapaxy must not ignore lithotomy, as sometimes he will come across a case where he can do nothing but lithotomy. Regarding dilatation of the urethra, if done within proper limits, I see no harm. As for the instruments, the makers ought to consult surgeons and follow their advice. Sterility in perineal lithotomy is due not to the incision but to extraction of a large stone through this incision. Pumping in of air is certainly the case with an evacuator.

PERINEAL LITHOLAPAXY.

By Lt.-Colonel H. W. STEVENSON, I.M.S.

By Perineal Litholapaxy is understood an operation for the crushing and evacuation of a vesical calculus through an incision made into the perineum, dividing the inferior wall of the urethra ; thus making an opening into the canal through which a portion of the urethra, and the neck of the bladder may be dilated. Instruments can then be introduced into the bladder which could not otherwise be made to enter it through the urethra, and stones can be crushed and removed, which must otherwise be treated by Lithotomy.

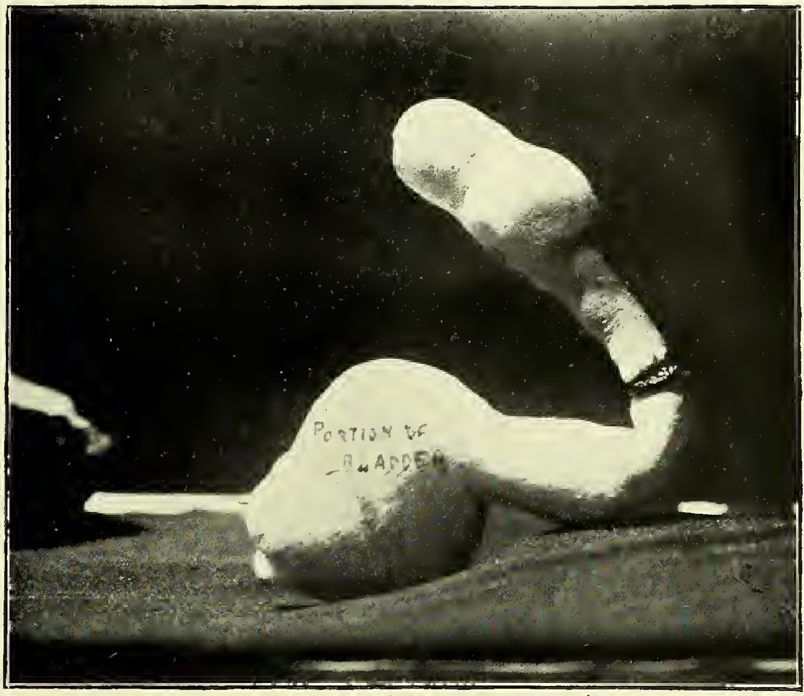
There are two classes of cases in which this procedure may be called for. Firstly, adult males suffering from stricture of the urethra combined with stone ; and secondly, boys.

In the first class the operation has the advantage that it may be utilized for the cure of the stricture, as well as the removal of the stone. It is, however, with regard to its usefulness in the case of boys that it is particularly brought to your notice in this paper.

All surgeons who have much experience of operations for stone meet with a considerable number of cases in which, either because of narrowness of the urethral canal, or on account of the size, or extreme hardness of the calculus, no instrument sufficiently powerful to effectively deal with the stone, can be passed through the urethra into the bladder. These are particularly met with in young boys. In these cases the question which the surgeon has to decide is "which is the best operation to perform, taking into consideration all risks, both of the operation itself, and the after treatment? No doubt the majority of surgeons would decide in favour of some form of Lithotomy. It is probable, however, that many would change this opinion had they more experience of Perineal Litholapaxy. In young boys it will be found to be an operation of much value. Lateral Lithotomy in boys is a very successful operation, so is Lithotomy by the suprapubic method, but both these operations necessarily involve considerable shock, and more or less prolonged after treatment. From these drawbacks Perineal Litholapaxy is to a great extent free. If carefully performed, it entails scarcely more shock than an ordinary Litholapaxy, and the small wound heals rapidly and requires practically no after treatment. It must be understood that the operation should only be had resort to in those cases in which the stone is of such a size that it can be crushed and removed. Rare cases do occur in which the stone is too large to be treated by Litholapaxy at all. These must perforce be treated by Lithotomy.

We are taught that the narrowest point in the male

A cast of the prostatic, membranous and bulbous urethra.



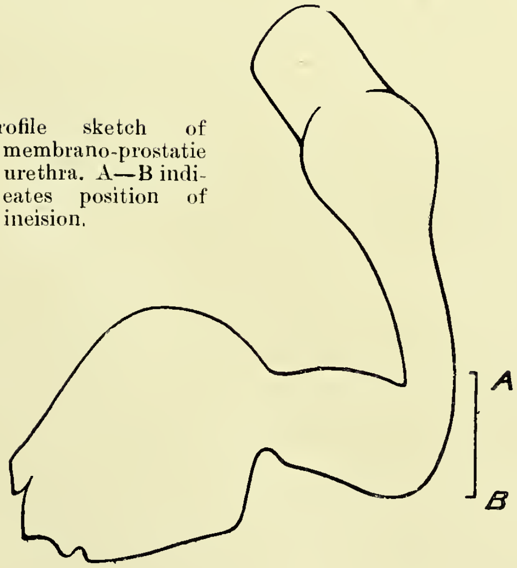
— Bulb.

— Membranous urethra.

— Fracture mended with sealing wax.

Ink mark showing limit of base of prostate.

'Horizontal' (Prostatic) urethra.



Profile sketch of membrano-prostatic urethra. A—B indicates position of incision.

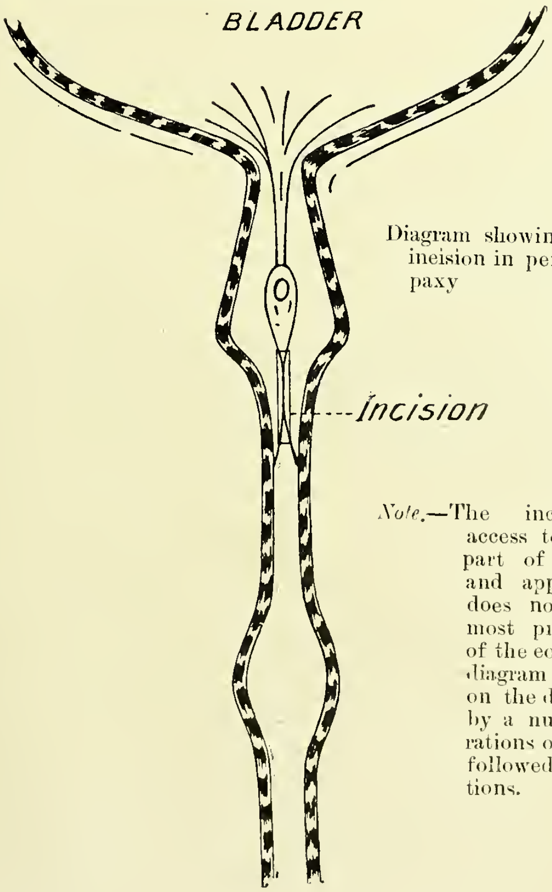


Diagram showing position of incision in perineal litholapaxy

Note.—The incision gives access to the widest part of the urethra and approaches but does not wound the most prominent part of the colliculus. The diagram was drafted on the data furnished by a number of operations on the cadaver followed by dissections.

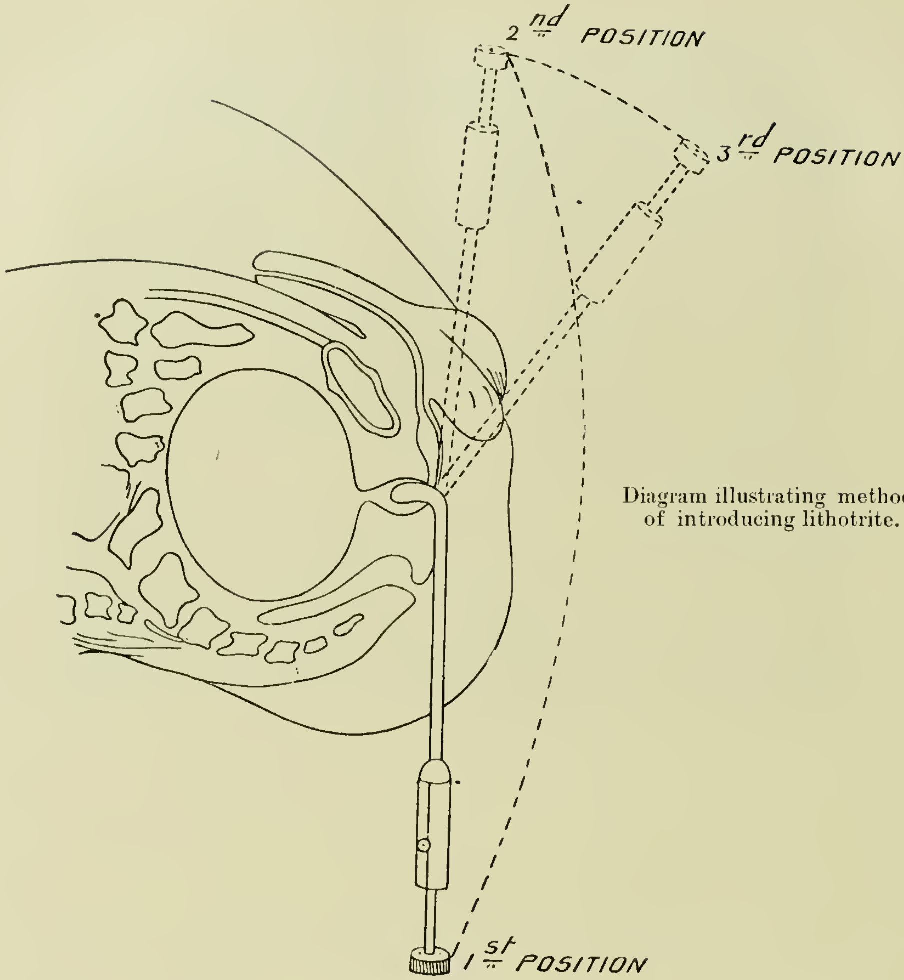
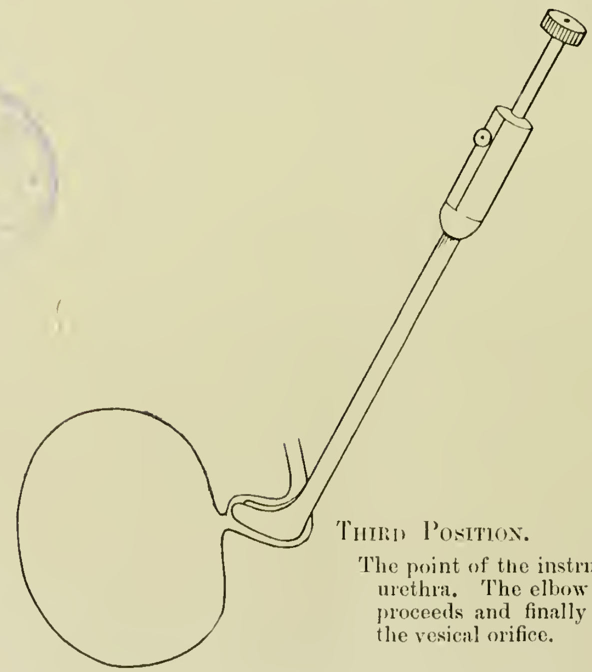


Diagram illustrating method of introducing lithotrite.



Third Position.

The point of the instrument raises the pubic face of the prostatic urethra. The elbow glides along the floor depressing it as it proceeds and finally drops into the hollow behind and below the vesical orifice.

urethra is the orifice, and that any instrument which will pass this ought, in a normal urethra, to go into the bladder. There is, not uncommonly, in the urethra of boys suffering from stone, a point where the canal is narrower than at the orifice. This is particularly found in boys with hard and rough calculi.

Any surgeon who has watched one of these boys will have seen that his hands are constantly engaged in pulling at the penis, and that a common way of trying to relieve the pain and irritation is by rubbing and squeezing the urethra against the border of the Pubic Arch, which affords a firm edge against which the urethra may be compressed. The constant friction, if continued for any length of time, leads to chronic inflammation and thickening of the urethral walls at this spot; forming a veritable stricture of the canal, through which it is impossible, without risk of great injury, to pass even a very small instrument. In these cases the stones are not usually large, but, being hard, require a fairly powerful lithotrite to crush them, and these are the cases which are eminently suited for Perineal Litholapaxy, and in which the operation is so valuable.

The operation of Perineal Litholapaxy is a simple one, and depends for its success on attention to certain details. As the technique of the operation may not be familiar to all it may be well to give a short description of it and to direct attention to the details which much affect its successful performance.

The instruments required are Lithotrites and Canulæ, a small central grooved lithotomy staff, an ordinary grooved director, a probe, a small pair of dressing forceps, and a narrow-bladed sharp knife. Female bladder sounds of two sizes are often useful for dilating the urethra, and neck of the bladder.

The patient is placed in the lithotomy position and the Perineum carefully cleansed. The small lithotomy staff is then passed into the bladder, and held by an assistant as in lithotomy, the bend of the staff being made prominent in the Perineum.

The surgeon, supporting with the left hand the scrotum and testes, places the left thumb upon the middle line of the perineum, feels for the staff in the urethra against which the tissues are steadied, and the skin drawn somewhat upwards.

The knife being held back upwards, the point is then passed through the tissues of the perineum straight into the groove of the staff, striking it at the bottom of the bend. The point of the knife is then pushed onwards in the groove for about $\frac{1}{4}$ of an inch, and as it is withdrawn, the wound is enlarged downwards in the median line for about $\frac{1}{2}$ an inch, or less After making sure that all the tissues down to the groove are cleanly divided, the knife is laid aside. The probe is now passed along the groove of the staff into the bladder and the staff is withdrawn. The director is now passed along the probe into the bladder and the urethra slightly dilated by gently separating the two. The probe is then withdrawn and the director left as a guide into the bladder. Along the groove in the director a small canula may now easily be passed, still further dilating the passage. As soon as the canula is in the bladder the director is withdrawn. The bladder should then be washed out and two or three ounces of warm Boric lotion left in it. The director must now again be introduced and the canula withdrawn. Along the groove of the director a lithotrite of sufficient power is now passed into the bladder—if any difficulty is experienced in doing this, the urethra should be further dilated by passing a larger sized canula or a female sound, along the director until the lithotrite passes easily. The lithotrite being in the bladder, the director should be withdrawn, and the crushing of the stone then carried out. Some trouble may be caused by the lotion running away beside the lithotrite and the bladder becoming empty. This may be met to some extent by the pressure of the finger of an assistant at the anterior margin of the anus, upwards against the shaft of the lithotrite, and by seeing that proper anæsthesia is maintained, and no straining allowed. If this does occur fresh lotion must be introduced into the bladder. The crushing and evacuation of the stone are carried out precisely as in ordinary litholapaxy until all fragments have been removed. The external wound and surrounding parts are then sponged clean, a little Iodoform dusted on, and the wound covered with a loose dry dressing which is secured by "T" bandage loosely applied. The legs are brought together and tied at the knees by a bandage for the first twelve hours or so. The external wound is usually completely healed within a week.

The details of the operation to which attention must be given are—

1st.—Complete anæsthesia. Any straining on the part of the patient renders the operation much more difficult.

2nd.—No larger incision than is absolutely necessary should be made.

3rd.—Preliminary dilatation of the urethra before attemtping to introduce the lithotrite. This must be carried out with all gentleness. The dilatation should be sufficient to allow the lithotrite to pass easily.

4th.—Never leave the urethra without a guide into the bladder. If the track is once lost it may be exceedingly difficult to find it again. It may sometimes be found again by passing the lithotomy staff, or by passing the probe through the perineal wound, but if this cannot be done easily, and with little delay, it is better to abandon the operation and allow the wound to heal up rather than run the risk of opening up the cellular tissue round the neck of the bladder.

5th.—Crushing must not be carried on in an empty bladder. It is sure to lead to bruising and injury of the walls, and probably to clogging of the lithotrite.

6th.—If after crushing and washing out, a small fragment still remains in the bladder, it may often be removed with the dressing forceps. A few words of warning may here be given regarding the use of the ordinary evacuator in all cases of Litholapaxy in young children. At Hyderabad, Sind, where a large number of these cases are operated on annually, the evacuator is rarely used, as it is found that it is perfectly feasible to clear out the bladder without it. Attention to this fact was first drawn by Brigade Surgeon Lieut.-Colonel Keith, I.M.S., who was formerly Civil Surgeon of Hyderabad,

and a brilliant operator. He showed that with an ordinary four ounce syringe to inject warm Boric lotion through the canula, aided by manipulation of the canula itself, and pressure, as required, above the Pubis on to the bladder, that viscus could be effectively washed out. This has since remained the practice at Hyderabad, and is most successful. It merely requires a little patience and practice. The use of the ordinary evacuator in the small bladders of these little children is by no means free from danger and owing to the small size of the canula necessarily used, is frequently very ineffective in removing debris.

It is to Brigade-Surgeon Lieut.-Colonel Keith also, that we owe the operation of Perineal Litholapaxy itself. He wrote a description of the operation in the "Indian Medical Record" of 1st December 1891 and, in the Annual Report of the Surgical Transactions of the Civil Hospital, Hyderabad, Sind, he speaks of it as "my modification" of Litholapaxy. Colonel Henderson, I.M.S, who succeeded him as Civil Surgeon, writes of the operation as "a most useful one, but one only to be used when the largest instrument which can be introduced is not powerful enough to crush the stone." The success attending the operation will always largely depend upon the ability of the operator to decide which cases are really suited to it and which are not. This can only be attained by experience. The tendency is towards using it in those cases where the stone is really too large, and ought to be treated by lithotomy. Such involve a tedious and difficult operation, trying to the surgeon, and sometimes fatal to the patient.

But, given the right class of cases, the operation is one of great value.

PERINEAL LITHOLAPAXY.

By Major S. EVANS, M.C.H., I. M. S.

The operation of perineal Litholapaxy is of very special and peculiar interest to an Indian Medical Congress. The operation of crushing and evacuation per urethram originated in another country. The application of the procedure to cases of stone in small boys owes its development very largely to the exertions of surgeons practising in this country. The operation of crushing and evacuation through a small mesially-placed perineal incision was born and elaborated in India, and owes its existence entirely to the work done by operators belonging to the Service of which I have the honor of being a member..

The point that strikes one most about this operation of perineal litholapaxy is that, although it is quite easy to perform, and although its results are strikingly good, it has never got a foot-hold in Europe, and that, even in this country, where opportunities for practice are unique in their abundance, it but shares a place, and often a very indifferent place, with other cutting operations. There is a reason for this. With the beginner in stone surgery there is the fear that having made an incision in the perineum he will find himself faced with a stone which he is incapable of delivering through the pelvic floor. It is quite a groundless objection and hardly needs discussing. It is otherwise with the practised operator. He knows that there may come a day when, having made his incision in the perineum, he may find himself, with a partially crushed stone in the bladder, unable to pass an instrument either through the perineal wound or through the urethra. Keith's successor at Hyderabad, Henderson, to whom I am indebted for my introduction to the operation, told me of two cases in which a lithotrite had been forced through the delicate tissues of a small boy's pelvic floor into the peritoneal cavity with fatal results. Surgeon-General Stevenson in his most interesting paper, and Major Smith during the progress of the discussion that followed, have drawn attention to this difficulty. Some four years ago I undertook a series of anatomical investigations with a view to elucidating the cause of the obstruction, and was able to devise an operation which is based on definite anatomical relations and is free from danger.

If a cast of the urethra be examined it will be seen that, beginning at the vesical orifice, the channel widens out steadily for $\frac{6}{8}''$ whence it suddenly narrows down again and takes a sharp turn forwards, being deeply angled inside the bend, to become continuous with the narrow cylindrical membranous urethra, which in turn curves forwards and upwards to terminate in the sudden and somewhat globular expansion of the bulb. That portion of the prostatic urethra which extends from the vesical orifice to the lower face of the bend, I will speak of as the "Horizontal Urethra," because it lies horizontally *in the Lithotomy position.* It is triangular in shape, flattened from before backwards, with its apex at the extremely dilatable vesical orifice and its base at the sharp prostatic bend. The narrow portion of the urethra appears in fact to spring from the anterior face of this base. It is very large and very dilatable. It will admit the fore-finger in an adult, and a No. 10 lithotrite in a boy of three. The operation of perineal litholapaxy aims at getting direct access to this 'horizontal urethra' without wounding the important structures which lie in its floor, and this access is obtained by placing the incision at A B shown in the diagram.

If, with the body in the lithotomy position, an ordinary bladder sound with a short beak be passed down the urethra, as far as it will go, with its *concavity* towards the perineum, its point will be found to project towards the surface. Mark this spot. It is the Bulbar point.

If, with the body in the lithotomy position and the abdomen and bladder laid open, a blunt style be passed in

through the vesical orifice of the urethra as far as it will go, it will be observed that the style lies parallel with the table, and that it projects the surface of the perineum at a point which we shall speak of as the vesico-meatal point. It lay in the bodies examined (all adults) $\frac{5}{16}''$ behind the bulbar point. If now the position of the vesical orifice be marked on the style before its withdrawal it will be observed that the 'horizontal' urethra measures $\frac{6}{8}''$ in length.

Pass a median lithotomy staff in the ordinary way; hold it vertically, neither pushing it down nor pulling it up; enter an ordinary straight bistoury at the vesico-meatal point parallel with the table; hit off the staff; elevate the handle of the knife and run it along the groove for a short distance; withdraw the knife and then the staff; now pass a probe in through the wound right up to the vesical orifice, preventing it from entering the bladder by a finger in the cavity of the organ; mark the skin surface on the probe and withdraw it. A measuring tape will show that the distance between the skin surface and the vesical orifice of the urethra, in young thin adults, measures $\frac{10}{8}''$ to $\frac{11}{8}''$. Subtract from this $\frac{6}{8}''$ for the length of the horizontal urethra already measured; we get $\frac{4}{8}''$ to $\frac{5}{8}''$ as the depth of the perineum from the urethra to the vesico-meatal point. When we consider that the beak of the smallest lithotrite in ordinary use, one never likely to be used in perineal litholapaxy, measures from point to shank $\frac{17}{32}''$, *i.e.*, is long enough to more than cover this distance, and, when we realise that this distance can be considerably reduced by pressing the shank of the lithotrite firmly against the perineum before rotating the handle in the manner to be described later, we should have no anxiety on the score of reaching the urethra with any lithotrite we may choose to use.

Pass an ordinary bladder sound, or median staff, in the ordinary way and when it is felt to "slip into the bladder," obtain a view of the interior of the organ through a suprapubic incision. It will be observed that *the whole of the curved portion of the staff lies in the bladder and that the whole length of the urethra from meatus to vesical orifice is perfectly straight, i.e., corresponds in direction with that of the shaft of the instrument.* The sensation felt when the instrument enters the bladder is in fact produced by the rounded angle between the beak and shaft slipping passed the base of the prostate. If now a needle be driven in, from the bladder, through the lower margin of the displaced vesical orifice, and parallel with the table, it will be found to emerge $\frac{17}{16}''$ behind the bulbar point and $\frac{8}{16}''$ in front of the anterior margin of the widely patulous anus of the cadaver. Or, to put it in another and more practical way, if the distance between the bulbar point and the anterior margin of the self-same patulous anus be divided into thirds, the needle emerges at the junction of the middle and posterior third.

Now we have got all our landmarks and are in a position to devise an operation based upon known anatomical relations. Hitherto operators have been groping in the dark. They have made their incision in a haphazard manner taking the so-called root of the scrotum "central point" of the perineum as their guides—landmarks which I have shown elsewhere vary in their position considerably—the result has been that, while in a large proportion of cases a safe spot was hit off, in a certain number the wide portion of the urethra was missed and difficulty and sometimes disaster resulted. The steps of my operation are as follows:—

The patient is anæsthetised.

The bladder is washed out with repeated syringes full of warm boiled boric lotion or sterilized salt solution. The process is completed with an evacuator.

With the patient still lying in the centre of the table, his limbs are drawn up into the lithotomy position and the *Bulbar point marked* with aseptic pencil or a nick with a scalpel in the manner already indicated. The *sound is removed.*

The patient is brought down to the foot of the table with his buttocks projecting well over it and his limbs drawn up into the lithotomy position.

The staff is passed.—With the ordinary median staff the limbs would have to be extended so as to relax the perinæal structures and allow the urethra to be distorted by the curve of the instrument in the direction of the patient's feet. With my own staff, which has a short beak sharp curve and bulbous point, this is not necessary.

Make sure the staff is in the bladder.—This is more necessary with the ordinary staff than with the instrument above referred to.

The staff is held as precisely as possible in the middle line and in a vertical position, neither pulled up nor pressed down, just in that position in fact in which it lies when it is felt to slip into the bladder.

If the scrotum is pendulous it is held up by one of the assistants holding the legs.

The incision.—The surgeon sits facing the patient's perineum. Keeping his eye on the staff, and perhaps lightly touching it with the thumb and two forefingers of the outstretched left hand, he enters a narrow sharp straight bistoury at a point, $\frac{1}{4}''$ in the adult, and somewhat less in children, behind the bulbar point. The edge of the knife is towards the table and the long axis of the blade is parallel with the table. The position of the incision is of considerable importance. It must involve the point where a style passed from within the bladder projects the surface of the perineum in the vesico-meatal point.

The staff can be felt, by deep pressure with the point of the finger, for some distance down the perineum. The lowest point at which it can be felt must not be taken as a guide to the point at which the knife should be entered. Just consider for a moment what I have said with regard to the anatomy of the parts, and the anatomy of urethral instrumentation, and you will see that if the incision be placed too far forwards the narrow membranous urethra is opened and no advantage will accrue over a Bigelow. Not only so but it lays the operation open to a very serious and almost prohibitive danger which I shall, with your permission, return to presently. If the incision be placed too far back the wide prostatic urethra is entered through the walls of the prostate and the sexual apparatus is in danger; or the urethra is not entered at all and the operation becomes a pre-rectal cystotomy. In either

case hæmorrhage is apt to occur from the important plexus of veins surrounding the prostate and neck of the bladder especially in old men.

The staff is struck with the first stab. Make sure, by a slight lateral movement, that the point of the knife is in the groove of the staff.

Raise the handle of the knife and run the point along the groove in the staff for about half an inch.

The wound in the soft parts is slightly enlarged as the knife is withdrawn. Remember that the incision must be only just large enough to admit the instruments one wishes to use.

A probe may now be introduced along the groove in the staff into the bladder, but this is not absolutely necessary.

The staff is withdrawn.

The surgeon now stands up. His left shoulder points towards the patient's right leg and he faces in a direction at right angles to the long axis of the table. In this position the remaining steps of the operation are completed.

A canula is introduced and a few ounces of fluid injected with a syringe, or run in from an evacuator with both taps open. The manner in which the canula is introduced is exactly like that presently to be detailed for introducing lithotrites.

The canula is removed. A finger may be placed on the wound as this is done to prevent escape of fluid should the patient strain.

The lithotrite is introduced. The instrument held with its handle pointing to the floor, and its beak parallel with the direction of the wound, is slipped along the newly made path to the bladder as far as it will go. With the shank pressed steadily against the perineum, the handle of the instrument is made to describe a half circle, around the point of junction of the beak and shaft, till the handle comes to point upwards, as shown in the diagrams. The handle is now drawn for a short distance in a direction away from the patient's head and the instrument allowed to glide gently into the bladder, by its own weight, remembering that the direction of movement is very nearly in that of the long axis of the shaft. By these series of manœuvres the beak is in the first place made to engage liberally in the 'horizontal' urethra. It is then so turned as to apply its points to the unwounded roof of the canal. Finally, its blunt rounded elbow is made to glide along the floor of the perinæal wound, over the lower angle of the wound in the urethra, and along the floor of the horizontal urethra depressing it as it proceeds in the direction of the long axis of the shank.

The remaining steps of the operation are precisely that of an ordinary litholapaxy.

The Hyderabad method of evacuation is useful in the earlier stages of the operation, but, I think, is an unsafe method to rely on entirely. I always finish with the evacuator and make certain with a sound in the bladder and a finger in the section that no grit is left behind. Even small particles are apt to interfere with healing and dim the brilliancy of results.

The cause of hæmorrhage has already been alluded to. It can be controlled in the following way :—An assistant stands facing the operator, and with his hand and arm well out of the operator's way, presses a fine close-textured sponge firmly into the perineum between the anus and the wound making pressure towards the pelvic cavity, *not* towards the shank of the lithotrite When the operation is completed the hæmorrhage will be found to have ceased.

Escape of fluid past the shank of the lithotrite, should the patient strain, is controlled in exactly the same way.

I must now return to the question we started with, *viz.*, the obstruction which occasionally arises in the operation tract—the bugbear of the old operation. Two classes of difficulty are met with: a temporary obstacle, hardly worth detailed attention, easily overcome by some accidental trick of manipulation gently conducted ; and a more serious and sometimes insuperable barrier to the further progress of the operation. These latter cases manifest themselves either at the very commencement of the operation when, after 'dilating' the wound with a female sound, the surgeon proceeds to introduce a lithotrite ; or later on, when he lays his instrument aside for a larger, and either uses firm pressure to pass it, or proceeds again to 'dilate' the wound before doing so. Let us consider, in the light of anatomical knowledge, the possible sources of error :—

1. The postural displacement of the perinæal structures produced by alteration of the position of the limbs may account for something. I have dealt with this question in detail elsewhere. Suffice it to say that very considerable variation within the limits rendered possible by careless assistants can be intentionally produced without giving rise to difficulty, or only such slight inconvenience as can be overcome by wriggling about a blunt director. It may account for some of the minor cases above referred to. Its remedy is simple and obvious.

2. The opening in the urethra may have passed out of alignment with the perineal wound, either because the incision was made too far back through the displaced prostate, or because the relation of the urethra to the more superficial structures was unnecessarily disturbed, by pushing the staff down against the perineum, or dragging it up under the arch of the pubes. An instrument (bulbous staff or sound) can in these cases be got into the bladder *per urethram* by keeping the point along the unwounded pubic surface of the urethra. No difficulty need be anticipated if the staff be held as already described.

3. The wound in the urethra may be placed too far forwards. This is important. It was the pitfall which beset the older operation, and which occasionally led to disaster. Let us consider such a case. The wound is placed in front of A B (see profile sketch); a narrow cylindrical portion of the urethra is opened, and, since the spot which usually stops a Bigelow is the urethra about the root of the penis, very likely a slightly larger instrument can be got into the bladder than could be introduced by way of the meatus. This does not satisfy the operator, and he proceeds to dilate the wound more effectually with a female sound, or, assuming that a little

extra force in an open wound can do no harm, proceeds to apply firm pressure with his lithotrite, the beak of which is possibly just engaged in the urethral wound. With the cast in front of us it is not difficult to imagine the result. The narrow cylindrical urethra is torn right across, and the operator is completely lost. He cannot get an instrument in by way of the meatus, and his chances of insinuating a probe into the proximal end of the torn urethra is very remote. His best proceeding under these circumstances is to reach the bladder through a supra-pubic incision. But this necessity need never arise. A glance at the profile sketch will show that, instead of 'dilating' or trying to force a passage, the surgeon ought to have enlarged the wound backwards with an inverted director or, better, perineal litholapaxy director, as a guide so as to involve A B in the slit.

4. The incision in the urethra may be too small. This might occur to anyone, and is especially apt to trouble those whose effort it is, and rightly so, to make their wound as small as possible. The obstacle need give rise to no anxiety. The wound should be enlarged towards the rectum on an inverted director. A perineal litholapaxy guide built for me by Arnold & Sons is a very useful instrument to use for the purpose. It consists of a bulbus grooved director with a longish handle set at an angle of rather more than a right angle to the director part of it. This instrument is introduced through the wound into the bladder. The handle, pointing upwards, is grasped in the full of the left hand, and held so that the ungrooved surface of the director presses gently against the pubic wall of the horizontal urethra. The knife is run along the groove with its edge looking towards the rectum and the wound enlarged to the desired extent. Care should be taken that the incision is not made too big or that the knife is not run too far forward on the groove so as to wound the floor of the horizontal urethra. It is better to make the section in two or three stages, trying an instrument after each cut, than to risk a gaping wound. Generally one slight nick is enough.

DISCUSSION.

Major H. Smith.—I thoroughly endorse everything which Surgeon-General Stevenson has said concerning the details of the operation of perineal litholapaxy, and in nothing am I in stronger agreement with him than in keeping a guide in the bladder. If a guide be kept in the bladder there will be no danger of losing our way. Those, with much experience of this operation, may be able to do without a guide, but few even of those experienced in litholapaxy have much experience in this operation as it is in a very small percentage of cases in which we require it. My own personal experience is that the percentage of cases in which we cannot do a urethral litholapaxy and in which cutting is not preferable to any form of litholapaxy is very small if we have a litholapaxy set of instruments ranging from No. $4\frac{1}{2}$ to No. 18 English scale. In that small percentage there is no operation to compete with perineal litholapaxy. I do not agree with Surgeon-General Stevenson as to the causation of the tight place in the urethra of the male child, which is just over the front of the scrotum. I have examined the bladder of children for other reasons than stone, and I find that this is invariably a tight place and I regard it as normal in the male up to the age of 4 years.

With regard to Major Evans' interesting paper.—It is interesting from an academic point of view, but I fear when the Surgeon is seated with his face to the breech of a patient, with a staff in the bladder, if he proceeds to measure in millimetres the site and size of his incision he will find himself in difficulties before he has finished, as such measurements however accurate theoretically, have a great tendency to get muddled up in his mind before he has finished. We wish to open the urethra just in front of the prostate. With a staff in the bladder and a finger in the rectum we can feel this point without difficulty and if we aim for it with the knife with such guide we will seldom miss it. I much prefer the douche described by Colonel Pank to the use of a syringe for distending the bladder and for washing it out. It is equally rapid and the pressure of it is a definite and known quantity, but I prefer a Bigelow's apparatus in good order to either.

Major V. Bennet, F. R. C. S. (Bombay).—Perineal litholapaxy has advantage in requiring no nursing, but it carries disadvantages too. The urethra in a boy is very delicate, and the depth of the perineum is very slight, and the repeated introduction of instruments must contuse the edges of the wound, rendering primary union impossible, because of the resulting molecular necrosis. On the 3rd to 5th day the edges swell up and prevent any escape of urine, which subsequently again escapes, to stop finally a few days later. The urethra and the skin are very close together, opening up thus the danger of epithelial cells growing over the edges of the wound, the resulting fistula thus requiring another operation. The supra-pubic operation has none of these drawbacks, the stitching up of the bladder being further facilitated by the hypertrophied muscular coat. The urine in boys is sterile, and if a few drops do exude out along a tiny drain which is left, no harm is likely to result. The drain is withdrawn after 48 hours, and the wound heals by first intention. I submit, therefore, that our decision should be that although perineal litholapaxy is a most useful operation in some cases, still the ideal to be aimed at is supra-pubic lithotomy with primary union of the wound. I should like to make a few remarks about another class of cases altogether which, I think, has not as yet been properly divided off, and in which a different style of supra-pubic lithotomy should be done. There are men who have had a stone for sometime which has attained a fair size. Their kidneys are damaged, there is albumen in the urine, very little nitrogen, and often micro-organisms. They give no trouble at the operation, but, on recovering from chloroform, they suffer from a peculiar girdle-like pain extending from the loins round the abdomen to the front of the bladder along the last dorsal ileo-hypogastric and ileo-inguinal nerves, undoubtedly reflected kidney pain; and with this there is suppression of urine. The slighter cases can be got round by vigorous dry cupping, but the majority form a good part of the mortality which occurs after litholapaxy. For these, the only operation is a rapid supra-pubic, with stitching up of the bladder wall to abdominal muscles to prevent extravasation of the usually septic urine into the perivesical tissue. If the wound is a large one, the upper end might be drawn together, but the operation must not be prolonged and a free opening should be left for the urine to drain away. I put this forward as a suggestion and a subject on which further enquiry is needed. Such cases fortunately are not very common. I have not yet had sufficient experience to speak with certainty on the subject In one of these cases, whose body I bought from his relatives in order to make a P. M. examination, I found the following condition. The walls of the bladder were over $\frac{3}{4}$ of an inch thick; either ureter would readily admit my thumb. Right kidney was nothing but a thin bag, the size of a child's gall-bladder, and the left one was about four times its normal size, of a dull white color and bore little resemblance to normal kidney substance. This was a case where I had done the supra-pubic lithotomy but had unfortunately closed the bladder wound. He had recovered well from the operation and six hours later his bladder contained about 8 ozs. of urine; as he could not void this, a Hospital Assistant passed a catheter in my absence. This simple operation *via* the urethra started the peculiar pain over the bladder and absolute suppression of urine, from which he died the next day.

Miss Staley, M. B.—In the Punjab, with the best of nursing we had 15-18 per cent. mortality in the supra-pubic operation. A syringe is safer than an evacuator in children. Chromic acid catgut was found very successful for stitching up the bladder.

Major Thos. Jackson, M. B. (Ahmedabad).—The accompanying fragments of a stone weighing 120 grains were removed by me by perineal litholapaxy from a boy, aged 2 years, on the 22nd January 1909. The penile portion of the urethra was so narrow that the smallest lithotrite could not be introduced into the bladder. By the perineal route a No. 8 lithotrite was easily passed and the stone crushed without difficulty. On the second day after the operation nearly all the urine was passed per urethram. The child was discharged cured on the 29th January.

2. This case illustrates well the value of perineal litholapaxy. By the ordinary method litholapaxy could not have been performed in this case ; by perineal litholapaxy, however, the difficulty of a narrow urethra was surmounted and the patient little more inconvenienced than if no resort had been made to the knife. By practising this operation a considerable percentage of cases of vesical calculi can be sucessfully treated by litholapaxy that would otherwise have to be submitted to lithotomy either supra-pubic or lateral perineal.

Col. Roberts.—An operation which is practicable in patients with a narrow urethra is very often sorely needed. When the urethra is very narrow I never do perineal litholapaxy by a median incision but by a lateral one. I reach the urethra not by cutting through the perineal tissues but by a stab. Cutting is likely to displace the structures. Regarding the leaking of the bladder in perineal incision, if the knife selected is just of the same diameter as the canula to be used, no leakage is likely in a lateral incision. Healing too is rapid in a lateral incision ; on the 3rd day the wound heals internally, and in 3—5 days urine ceases to escape from the wound. I know of no sterility occurring in my three cases of lateral incision, and have found it far superior in gaining easy access to the bladder as compared with the median incision.

Major A. Street, F. R. C. S.—I see no necessity to procure more room, and thus a lateral incision is not necessary. I have seen no leakage after the 1st day with a median wound ; there is no risk of missing the urethra if the perineal skin is kept fixed, and if the stab and not " cutting " is done. The narrowest part in a child is not the meatus, but the cause I think is anatomical and not pathological : a muscular spasm due to irritation. Major Smith prefers to do perineal litholapaxy only in certain very few cases. I think it is more needed in children than adults, the stone often being much larger, a child's urethra not being so distensible, and because incision in a child heals very rapidly. I know of a case where jamming of a lithotrite did occur in spite of enough water in the bladder.

The President.—Discussion on " the point of incision" is more academie than practical ; we go more by feeling the surrounding parts. As for the jamming of the lithotrite, a prevention I think is to crush up as much as possible with every introduction of the instrument, and thus avoid frequent introduction. A No. 4 Arnold's lithotrite, with a grip of 1½ inch I have found very useful for soft stones. I would not agree with Major Smith that perineal litholapaxy wouldn't be much needed if we had a larger variety of lithotrites ; in children with hard stones no other operation is possible. If the narrowness of the urethra in children is due to spasm as suggested by Major Street, it ought to disappear under chloroform, but it does not.

Miss Staley remarked that she knew of 13 cases of dilatation of the female urethra, of which all but two recovered completely within a year.

Major A. Hooton, I. M. S.—I have listened with great interest to Major Evans' remarks on perineal litholapaxy, and think he is to be congratulated on having approached the subject from an original and very practical point of view. The operation I regard as a most valuable one, and it has always struck me as remarkable that it has not been more generally taken up : even in India it appears to be very local, whilst the only perineal crushing operation at present described in the standard English text-books, so far as I am aware, is the old procedure which goes by the name of Dolbeau, in which a median cystotomy is first performed. Now the essence of Keith's operation is that a urethrotomy, not a cystotomy, provides the alternative route for the larger instruments which cannot be passed by the natural channel.

Keith's operation has always interested me greatly. Like Major Evans, I first learnt it from Colonel Henderson, and I remember years ago writing a description of the procedure to accompany a short article for the British Medical Journal, which Colonel Henderson was good enough to check. As his account differs somewhat from Surgeon-General Stevenson's it may perhaps be worth while to recall it in the present connection.

The main objects of the operation were, so far as I am able to remember, as follows :—

To strike the urethra in a superficial part, and so avoid any unnecessary injury to the tissues and to open the membranous portion, thus doing away with the resistance of the fibres of the compressor urethræ muscle, spasmodic contraction of which often causes some obstruction to the passage of instruments, and increasing the calibre of this narrow portion of the canal. Colonel Henderson laid great stress on not touching the skin, or even raising the scrotum, when making the incision, so as to avoid the risk of a valvular opening, which might be caused by traction on the parts ; he dilated slowly, leaving in each instrument a minute or two, so that at the end of the process a distinct circular gaping orifice could be seen, into which a canula could easily be passed ; and he used no guide, after the completion of dilatation, which was performed, as Surgeon General Stevenson described, along a director. I have found Hegar's dilators very useful in this part of the operation. The incision was to be from ½″ in boys to 1″ in adults in front of the anus, thus avoiding the bulk and hitting the membranous urethra behind it. Carried out in this way I would urge that a smaller opening is made, and that there is therefore less chance of leakage than when the constant pressure of a guide is insisted on.

Major Evans' proposals constitute, if I understood him rightly as incising the prostatic urethra, a new modification of perineal litholapaxy, and I should like to make a few remarks on them ; it seems to me that in the first place his wound is deeper and altogether of a more serious character than in the old operation ; then, again, he strikes the channel at a point were it is not so muscular, and will therefore be more likely to leak ; and I think, personally, that he is even more likely to miss his opening during re-introduction of instruments, owing to the fact that he has to approach it at an acute angle and far from the surface instead of, as formerly, under the opposite conditions.

As regards space, I have always found that the channel afforded by Keith's operation gave ample room for all practical purposes.

With regard to the locking grip of lithotrites one is dependent on the instrument makers, and I think the tendency amongst them is to restrict the scale too much. Messrs. Weiss are, I suppose, the best known makers of these instruments, and their ordinary scale is as follows :—

No. 5 with ⅜″ grip ; No. 6 with ½″ grip ; No. 7 with ⅝″ grip ; No. 8 with ⅝″ grip ; No. 9 with ¾″ grip ; No. 10 with 1″ grip ; No. 11 with 1⅛″ grip ; No. 12 with 1¼″ grip ; No. 13 with 1⅜″ grip ; No. 14 with 1½″ grip ; No. 15 with 1½″ grip ; No. 16, 17, 18 with 2″ grip.

This is, I consider, too restricted and after some correspondence I prevailed on the firm to increase the grip of the instruments in the Rajkot Hospital by ¼″ upwards. This has resulted most satisfactorily, and I have now used these altered lithotrites with the greatest comfort for some time, crushing stones with ease that would otherwise have had to be removed by a cutting operation. I consider that the scale quoted above could be with perfect safety increased by ¼ inch, up to No. 6, by ⅛ inch, from No. 7 to 10, and by ½ inch from No. 11 upwards, and in

this country, where the operation is of such great practical importance, I would suggest that steps should be taken to obtain instruments of at least that range. Another point which was raised some time ago by Major J. B. Smith, is the standardisation of canulæ and evacuators, the want of which results in much annoyance to the surgeon and considerable waste of Government money.

As regards the relative merits of lateral and suprapubic lithotomy I would beg to express a different opinion to Colonel Pank's. I think, as he does, that the vast majority of stones should be treated by ordinary or perineal litholapaxy, but that the remainder, mostly very large calculi, would be best removed by the suprapubic route, as a rule.

RHINOPLASTY.

By Major H. SMITH, I.M.S.,

Civil Surgeon, Jullundur, Punjab.

To repair the deformity caused to the soft parts of the nose by syphilis, lupus or the knife of the criminal has taxed the ingenuity of surgeons for a long time. The passer-by always points at the individual without a nose, and in very many instances points at the individual whose deformity the surgeon had endeavoured to remove as "the man with a nose." In India the nose is a term in an idiom of the language, "such and such a thing is the nose of the place," meaning respectability, dignity, &c., not properly translatable but intelligible when we consider the reverse—a person without a nose—which is the brand of the unfaithful wife or of her paramour. The Indian operation as described in the recent edition of Jacobson's two vol. book on surgical operations is probably the most ancient of them; it is the primitive and immemorial operation of the Indian barber. He describes the Indian operation known as Keegan's of 1891, but does not recognise the Indian operation as described in Keegan's recent monograph which is the Indian operation of the present day. The Indian barber's operation may safely be relegated to a historical position. Photo 6 shows the result of the Indian barber's operation. It will be observed that the barber in this case took a considerable flap from the forehead, which appears on the tip of the nose, having shrivelled up to look like a knob the size of a small horse bean. This was the invariable result of the Indian operation done as the barber did it. The Italian and all operations with a flap from the face are destined to the same shrivelled result from the reason constant in them all, *i.e.*, they do provide for a lining of epithelium for the interior of the new nose and thus put on a single flap epithelium covered on the outside only and leave the under-surface of the flap raw; the consequence is that the raw surface left cicatrices and shrinks and leaves the patient no better off than he was before as regards the nose, with in the case of the nose made from face flaps the intense disfigurement of the facial scars.

Of the three operations, the Indian Barber's, the Italian and the British, the Italian leaves least disfiguring scars as they are on a region not exposed to view. The Barber's leaves much less deformity than the British as being on the forehead it will pass for an accident such as the kick of a horse, and hence the lay public pay little heed to it. The same holds good if skin grafts have been put on and have failed to take, but grafts on the forehead should not fail and hence the deformity should hardly be noticeable. Grafts on the face are much more likely to fail (1) because if put on at the time of operation it is very difficult to stop all oozing and (2) because of the fat on which they are put. Grafts when we wait for granulations are never so satisfactory as if put on at the time of operation.

The British operation which scars the face is noticed by everyone and by the lay public is put down to syphilis. The Italian operation, apart from the shrivelling of the result constant in these three operations, must be unbearable from the constrained position of the arm during the time of uniting.

The facial flap operation has the great disadvantage over the Italian and the immemorial barber's operation in that the flaps have a great tendency to slough, a point not put forward by its advocates. Why this should be I think is evident. There is nothing in it to support the nutrient vessels but fat—a very bad medium in the case of such small flaps. I have done the modern Indian operation now 39 times and am confident that with any reasonable care it should never slough—I have not yet had one slough. The reason why it has so much more vitality than the face flap is to me evident; we take the flap down to the periosteum and thus it has its nutrient vessels between the skin and the frontal aponeuresis which protects them and it has as its nutrient vessel the strong frontal branch of the ophthalmic artery. Jacobson says that the Indian operation, I presume the barber's operation, has a tendency to shrink and fall flat in the tip. It is interesting to note that in describing Syme's or the British operation he does not draw attention to this same tendency, an operation which gives the same shrivelled result as the Indian barber's operation for the same reason, *i.e.*, it is made from a single flap.

With Colonel Keegan, I.M.S., rests for all time the credit of the ingenuity and powers of observation which has made rhinoplasty one of the most satisfactory operations in surgery. How strange it is that the surgeons of the world outside India still hesitate to follow where he led; men are by nature conservative creatures and hence it is more pleasing to follow the lead of men of past ages than to follow men now living. Keegan's grand innovation was to reflect the skin of what nose remained to form an epithelial lining for the new nose and to cover the freshly exposed nasal skeleton and the reflected skin with a flap from the forehead. Thus the new nose

consisted of two thicknesses of skin, the raw surfaces adjacent, the epithelium of the reflected skin on the inside of the nose and of the frontal flap on the outside, with the frontal aponeurosis between; hence the nose does not shrink. This is the keynote of the success of the Keegan nose. It has a tendency to droop or fall a little flat at the tip from want of the support of a septum. It was hence, and is still, advisable, in putting on a new nose, not to aim at making it too long, but to put on a nose just sufficiently long to cover the deformity as such is less liable to fall flat than a long nose; but here I do not imply that there should be any half measures in putting on a Keegan nose; the deformity can and should be decently removed as regards the size of the nose put on. The frontal flap has the great advantage of being heavy tissue with great vitality.

It rested with me to complete what Keegan began, *viz.*, to add a new septum to the Keegan nose. In what follows I substantially describe Keegan's operation with the addition of a septum made out of the spare portion of the flaps reflected from the nasal skeleton. The amount of tissue reflected from the remaining nose as well as the size of the frontal flaps depends on the space to be covered in and is much or little according as it is much or little. If all the soft parts below the skeleton have been removed by disease or by the knife of the criminal our flaps must be liberal. I cut across the nose about where a spectacle frame rests, half an inch on either side of the middle line in a case in which I require much tissue; the line ABC in Diagram 1. From the middle of this incision I make another down the middle of the dorsum of the nose and down the septum into the upper lip $\frac{1}{4}$ inch below the original seat of the columella (the line BNK in Diagram 1, and separate the soft tissues from each side of the cartilaginous septum which remains so as to get the flaps when brought down inserted well back. The gap to be covered is bounded in Diagram 1 by the line FNG and HH. Next make the incisions in the

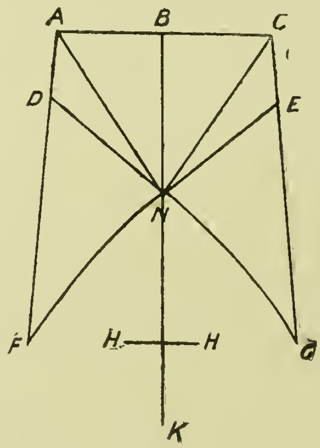


Diagram 1.

line AF and CG, the points F and G being in sound tissue in the remains of the ala nasi or where the ala nasi on either side should be and reflect the flaps downwards on the hinges FN and GN. It will at once be seen on reflecting these flaps on their oblique hinges FN and GN that they will overlap and that the pieces DABN and ECBN will be spare tissue. This spare tissue Keegan removed and stitched the edges DN and EN of the flaps together. These spare pieces I curl over and insert each into its respective side of the septum and steeple them together with a stitch near the dorsum; this stitch will pass through about the middle of the lines AN and CN, and trim the ends to my fancy. By this method when we have got so far the nostrils stand out prominently and open, whereas by Keegan's method at this stage the united flap tends to fall in. When I have got so far I carefully control all oozing. I next cut a piece of paraffin paper or any such material to the exact size required to cover the raw area and to make a columella. This pattern I lay on the forehead, the base of it inclined to one side and I continue the original incisions BNK along one border of the pattern which I follow right round until I cut through the inner border of the eyebrow, taking care not to injure the frontal branch of the ophthalmic artery on which the nutrition of the flap will depend. In cutting this flap, the paraffin paper being the exact size I require, I take a little more tissue all round than the size of the pattern so that there will be no tension on the flap when stitched in position. At this stage all bleeding is controlled. The flap is now brought down and neatly stitched in position. The free border of the flap is also carefully stitched to the free border of the nostrils made from the flaps reflected from the nose. At this stage a deep transverse incision (HH) about half an inch long is made where the columella is to be inserted, and the epithelium pared off $\frac{1}{4}$ of an inch of the columella tail of the frontal flap which is fastened in this incision with a couple of fine stitches. A few fine stitches unite the edges of the columella with the newly made septum. The next stage is to pass a few stitches in the scalp at the angles of the bare surface on the forehead so as to control the last traces of oozing and to put on sufficient skin grafts to cover the raw surface easily. These I always put on at the time of operation and I seldom see a single one of them fail. It is important of course that the last trace of oozing should be stopped before the grafts are put on as on this depends the success of the grafting.

About three weeks after operation the stump of the flap and any spare skin over the bridge is excised by an incision running down the middle of the dorsum as far as the terminal ends of the nasal bones and another round the stump running into this incision on the dorsum. At the same time the frontal aponeurosis is dissected out from under the flaps all over the nasal bones so as to leave the new nose fine over the bridge, and the wound is united with a few points of suture.

Diagram (2) shows the shape of the frontal flap and about its size—its size of course depends on the area to be covered. The dotted line shows Keegan's flap which I found did not give as good a result as the convex flap adjacent to it. It will at once be seen if the skin be reflected from a normal nose from below upwards that the lower border will be convex. Photograph 7 shows

Rhinoplasty.

No. 1.

No. 2.

No. 3.

No. 4.

No. 5.

No. 6.

No. 7.

No. 8.

No. 9.

No. 12.

No. 10.

No. 11.

the deformity on the dead subject. Photo 8 shows the flaps to be reflected from the nose outlined. Photo 9 shows the flaps from the nose reflected down to form the lining membrane for the new nose and the artificial septum made out of them. It also shows the frontal flap outline. Photo 10 shows the frontal flap stitched

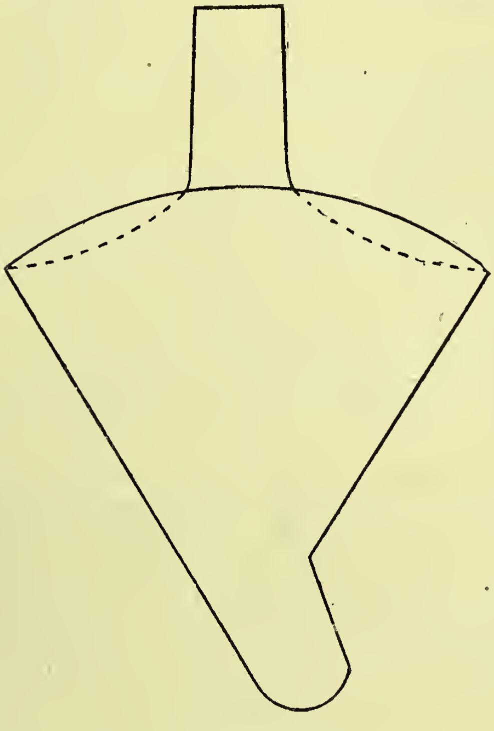


Diagram 2.

in its final position, and the space to be grafted on the forehead. This is not a good photograph as the left angle of his mouth has fallen down and makes his nose look shorter on this side than it really is or rather makes the upper lip look longer than it really is. The subject was not a good one as he died of a wasting disease and hence the tissues over the forehead and nose were very thin and wasted. The other photographs require a note. There is but one of them in which I have a photo of the deformity before operation. So far I have not paid any attention to photos; we have no professional at Jullundur and hence I have to depend on amateurs. If I keep one of these patients over to get her photo the chances are that she will have gone home before the following day, hence I do the case as soon as it arrives at hospital and thus I have but a small collection of photos of the deformity. Much the same applies to the results of operation. The new nose remains for some time œdematous and one is ambitious to let it become as fine as possible before taking the photo, and here I have almost always found that the patient had slipped away from hospital before we got her photograph, and as my cases have nearly all been from a long distance it is almost impossible to get them back for photographic purposes.

Photos 1 and 2 are of the same patient. In 2 she is shown in a somewhat side view so as to show how little scar there is on the forehead when grafted, as that part of the forehead shown is that from which the flap was removed. Photo 3 shows the result in a nose eaten away by syphilis and also shows how little noticeable is the scar on the forehead; I have not got his original photo. His nose and that in No. 2 are a good deal coarser than they would be six months after operation when the œdema would have disappeared. Photos 4 and 5 show how much we are called on to repair; in both of these a piece of upper lip was removed with the nose. Photo 6 shows the result of the Indian barber's operation; it will be seen from it that the terminal portion of the flap—the single flap—shrivelled up. Photo 11 shows a nose a year after, the only one I have been able to get a reasonable time after operation. In it the œdema has disappeared. It also shows how little scar is on the forehead. This photo shows how well the tip of the nose stands out and how open the nostrils remain, both of which are the result of the septum made from the flaps reflected from the nose. A well done nose is noticeable only to the eye of an expert. The man in the street does not notice that anything has happened. In fact I once extracted a pair of cataracts from a patient on whom I had put on a new nose and it was only when my assistant was dressing up the eyes on the table, that he noticed it and drew my attention to it. It can be inferred that there was very little scarring and no deformity when it passed both my assistant and myself so far. I once had to give evidence in the law court in a case in which the Crown was prosecuting a man who had cut off the nose of another, six months after the offence was committed. I had operated on the case. The defendant's counsel pleaded in his defence that the deformity caused was *nil* and that the accused should in consequence be acquitted or let off with a trifling punishment on that account. As a matter of fact that anything had happened to the man's nose would only be recognised by an expert.

In dressing up these cases drainage tubes should not be inserted in the nostrils as they are not required and they tend to interfere with the union of the new septum.

Photo 12 shows a nose recently put on a patient from whom all the soft tissue below the nasal bones was scraped out with the knife.

DISCUSSION.

Capt. Jamison inquired whether the flaps taken from the nose would not slough.

Major Smith stated that he had never seen them slough.

CHRONIC, GASTRIC AND DUODENAL ULCER IN INDIA,

A Study based on 70 Cases in which Gastroenterostomy was performed.

By W. J. WANLESS, M.D.,

Surgeon, Presbyterian Mission Hospital, Miraj, S. M. C.

The first gastroenterostomy performed by the writer for the relief of chronic ulcer of the stomach was done in 1897. Since that time he has operated one hundred and sixteen times for the relief of chronic gastric and duodenal ulcer and allied conditions. All of the seventy cases herewith reported were performed within the past two years, of these 39 were done within the present year. The increasing number of patients applying for surgical relief in the Miraj hospital for the above affections has led the author to investigate to some extent the prevalence of chronic gastric and duodenal ulcer in India generally.

Very little has hitherto been written on this subject in India apparently for the reason that chronic gastric and duodenal ulcer are considered either an uncommon disorder or are still regarded as a disease requiring only medical and diatetic treatment. More probably, however, the disease has been to a considerable extent overlooked by the subordinate medical staff to whom the majority of these patients necessarily apply for treatment in Government dispensaries.

In July, 1907, the writer addressed a letter of enquiry to the Senior Medical Officer in charge of principal presidency hospitals. Replies were received from three of the four institutions addressed. These replies show that in 1907 there were admitted into these institutions seven cases of gastric ulcer (one of which was acute) and two cases of duodenal ulcer. Two of these institutions admitted forty cases of chronic gastritis. No operation for the relief of gastric ulcer is reported in any of these hospitals in the year for which the report was made.

While the data furnished by the replies received is not comprehensive enough to warrant, on the one hand, the conclusion that chronic ulcer of the stomach and duodenum are rare in the districts represented, or the assertion on the other, that such cases are generally not diagnosed, it would seem at least to indicate, bearing in mind the great prevalence of gastrointestinal disorders in India, that the proportion of gastric and duodenal ulcer reported in the public medical institutions of India is below what might be expected were the facts actually known. Be this as it may, the writer is convinced of the relative prevalence of this condition in Western India.

In the Miraj Mission Hospital a record is kept of the residential distance of all patients. Of the seventy operations herewith reported it was found that the first 30 cases came from villages within eighteen miles of Miraj, but for the entire series the average distance per patient from Miraj was one hundred and thirty miles and for the last 25 cases the radius increased to one hundred and fifty-five miles. As the knowledge of available surgical relief for this most distressing affection extends, it seems probable that the disease will be found to be prevalent in districts where hitherto it has not been sufficiently observed or the importance of its surgical treatment recognised.

The Prevalence of Chronic Gastritis.—Referring again to the abovementioned questions and answers it was observed that in 1906 there were twenty-five cases of chronic gastritis treated in the Madras General Hospital, and fifteen cases in the Lahore General Hospital. Presumably these cases were accurately diagnosed, but it seems to the writer remarkable that a larger number of cases of the allied condition of chronic ulcer were not admitted, inasmuch as this disease induces a severer train of symptoms than those of chronic catarrh or gastritis.

Then again as one peruses the average dispensary register in India he will find a large percentage of gastrointestinal disorders recorded as "dyspepsia," "gastric catarrh," etc. In view of the fact that chronic gastritis in western countries is, according to the most recent observations, a comparatively rare condition in the category of gastric diseases, it seems probable that many cases hitherto reported as "chronic gastritis," "dyspepsia," etc., are really cases of chronic ulcer. This statement is borne out by several of our operated cases in which the symptoms were comparatively mild and which might easily have been clinically diagnosed as "gastritis," but which at operation showed unmistakable evidence of ulceration either in the stomach or duodenum.

Professor Chase of Boston quoting Riegel says "chronic catarrh of the stomach is not a frequent disease. If we cease to force all known gastric disorders into a few disease categories, and rely only on positive signs of this condition, we shall soon learn that chronic gastritis is not so frequent as many modern writers still persist in believing." Quoting Stocton, Professor Chase continues "the comparative infrequency of chronic gastritis will be endorsed by experience if the cases were carefully studied." Of his own experience Professor Chase says "Primary chronic gastritis is encountered once in about every 200 to 400 adult patients in a general medicinal clinic, not so often as gastric ulcer. Of 100 consecutive cases of gastric disorders taken from my private records in which the stomach contents were examined, 9 presented the objective findings of chronic gastritis. The percentage (9 per cent.) was greater than I had expected, but it should be stated that more than one half of the number from which these cases were taken were cases referred by physicians and represent usually severe types of gastric affections."

One does not know how generally prevalent cancer of the stomach is in India, though, in the writer's experience, it appears to be about as common as it is in American

clinics familiar to him. The now well known facts of chronic ulcer as the starting point of cancer of the stomach (according to Mayo 50 per cent. of all gastric cancers are engrafted on benign ulcer) and judging from the number of cases of gastric cancer observed by the writer, the statement that chronic ulcer of the stomach is more common among the natives of India than is generally supposed, seems warranted.

Causation.—The excessive use of alcohol, farinaceous food, overeating, etc., the recognised predisposing and active causes of chronic gastric ulcer in western countries can hardly be regarded as important factors in the causation of this condition among the natives of India, who are not generally addicted to alcohol and flesh as articles of diet. We must therefore look for the causes of gastric and duodenal ulcer in other articles of diet and manner of living than those of Europeans.

As the result of enquiries among this class of patients and among those familiar with the diet used by the natives of Western India the writer believes the following to be the principal dietic causes of gastric and duodenal ulcer in these parts.

1. *Coarse, poorly cooked food.*—Of the seventy cases herewith reported some eighty per cent. belonged to the working classes and came from districts in which the staple food is unleavened cakes (chapaties) of zondla (zwari) and bajri, with rice, curry and vegetables. The flour made from these cereals is coarse and the cakes usually tough and poorly cooked. The rice though usually well cooked is eaten cold and very highly spiced with curry. A very common practice on the part of the natives, I am told, is the eating of raw pepper (capsicum) with their food, which cannot but excite undue stimulation of the circulation in the gastric mucosa as well as the musculosa, the rough food meanwhile inflicting continual trauma in the grinding portion of the stomach at the pyloric end, the usual seat of chronic ulcer. Hyperacidity is probably also produced by this excessive stimulation of the stomach which in turn results in duodenal ulcer, since it is well known that practically all duodenal ulcers occur in the first portion of duodenum the result doubtless, of the digestive effects of the excessively acid chyme, or chyme as yet unneutralized by the alkaline biliary and pancreatic secretions.

In districts where rice is the staple article of diet and curry is not eaten in excess or vegetables are not eaten in a comparatively raw state we can imagine that ulcer would be less common than in districts where the diet is largely such as mentioned above.

2. *Large infrequent meals.*—One cannot observe the enormous pile of rice, etc., that a native will eat at a single sitting, without suspecting that he must at some time or other suffer from excessive gastric secretion, dilatation of the stomach and stagnation of food as the result of such continuously repeated engorgements. Insufficiency of the pylorus, the result possibly of this overdistension, allowing excessive quantities of acid chyme to be rapidly thrown against the relatively vulnerable mucosa in the first portion of the duodenum produce both a traumatic and digestive effect upon that structure.

Sex.—In this series sixty-four were males and six females, about the same relative frequency exists in western countries. No satisfactory explanation can be offered regarding the preponderance of the male sex as subjects of chronic ulcer while the opposite fact usually obtains in cases of acute ulcer. The lower anatomical position of the duodenum believed by some writers to exist in women may account for it, this position securing more effective natural drainage of the stomach.

Age.—There was one case below twenty years of age (a female without demonstrable lesion); 11 between twenty and thirty; 30 between thirty and forty; 18 between forty and fifty; and 8 between fifty and sixty and 2 over sixty years of age. (Approximate ages).

Occupation.—Sixty-four of the patients belonged to the laboring and servant classes; six were registered as clerks, writers, etc. These figures do not, however, truly indicate the relative frequency of ulcer in these two general classes, since the last-named are better able to carry out prolonged medical treatment and submit less readily to operation than the first-mentioned class.

History.—Most of these patients gave a history of long standing indigestion, 14 stated that their symptoms began with indigestion, vomiting, etc., more than ten years previously; 15 five to ten years; 19 three to five years; 5 over two years, and 14 for one year or less.

Pathology.—The post-mortem pathology of chronic gastric ulcer is sufficiently described in the text books, reference here will be made only to the lesions observed at operation. In seventy cases in which a provisional diagnosis of ulcer had been made prior to operation, visible or palpable indurations or scars representing ulcers were found in the stomach including the pylorus in 28; in the duodenum 34, and in duodenum and stomach 5. All of the visible scars in the stomach, with a few exceptions, were found either in the superior border or lesser curvature (saddle ulcer) or on the anterior surface; all of the gastric lesions were confined to the pyloric end of the stomach. In the duodenum they occupied any part of the wall but were chiefly confined to the vestibule and first portion. In several cases the head of the pancreas was found to be hard, thickened or enlarged in consequence of the adjacent ulcerative process in the duodenum. Stenosis, due to thickening and contraction of the pylorus, was present in twenty-two cases of gastric ulcer and well marked stenosis of the duodenum was noted in five cases. The duodenum lends itself to dilatation more readily than the pylorus, hence the infrequency of stenosis in that portion of the gut. A one-sided dilatation of the duodenum was observed in several instances of duodenal ulcer. In one of the duodenal cases the first and second portions of the duodenum were represented by a cord-like tube greatly reducing its calibre. Adhesions were observed between ulcer area and omentum, liver, gall bladder or abdominal wall, in 19 of the seventy cases. In several instances the pylorus or duodenum or both were found to be fixed by dense adhesions. "Sentinel" glands were observed in eleven cases. In eight cases the stomach at operation was noted as greatly dilated; in all these cases stenosis was present to a marked degree. Gastroptosis

apart from dilatation was rarely observed. In one case, a neurotic patient, not included in this report, in which ulcer was suspected, no gross lesion was found and the abdomen was closed, operation on the stomach being deemed inadvisable. In two of the seventy operated cases no gross lesion was found. In one of the series in which there had been all the subjective and objective symptoms of the ulcer, the stomach was found contracted, in another case no demonstrable lesion was observed, though the symptoms pointed to ulcer. The first of these was entirely relieved of persistent vomiting. The second was partially relieved but subsequently developed pulmonary tuberculosis.

An unobserved tubercular lesion may have been the cause of the symptoms in this case. Apparent hypertrophy and spasm of the pylorus was noticed in both of these cases. Hypertrophy of the stomach wall was observed in a considerable proportion of the cases of duodenal ulcer and in one case of gastric ulcer in which there was no apparent stenosis. Thickening of the stomach wall was usually observed when stenosis was present. In one case of distinct duodenal lesion with adhesions to the liver, a loose kidney, capable of being pushed into the abdominal wound by pressure on the loin, was observed. The gastroenterostomy relieved his symptoms and nothing was done to anchor the kidney. In one case of duodenal ulcer the lymph channels in the mesocolon were found hard and calcareous. Cancer was suspected on account of the excessive thickening in two cases, and in one the lesion was unmistakably cancerous, though no tumor was palpable through the unopened abdomen.

Symptoms.—About fifty per cent. of these patients were admitted with history and symptoms so clear as to leave no doubt even after a rather cursory examination as to the presence of chronic ulcer either of the stomach or duodenum. Our rule, however, has been to practise lavage in all cases on admission and for several days subsequently in order to determine the advisability or otherwise of operation. At the first examination the size of the stomach is outlined by filling or partly filling the stomach with water or by distension with air pumped in through a stomach tube by means of a Davidson's syringe and outlining the stomach by percussion before and after the use of water or air. We have made use of Einhorn's electric stomach lamp and distension with water to which bisulphate of quinine is added for fluorescent effect, but generally we have found the distension of air or water sufficient. Indeed we do not now for practical purposes consider the determination of the size of the stomach essential in the absence of palpable tumor and the presence of retention symptoms. Following the preliminary examination all patients are given daily lavage, a test meal is usually given, and a gastric analysis made within a day or two of admission. Patients are then allowed ordinary food and each morning twelve hours after the last meal lavage of the stomach is practised and the character of the return fluid noted. In the meantime the subjective symptoms are noted and recorded.

It is not always easy to distinguish gastric and duodenal ulcer, but inasmuch as the treatment is the same in both lesions, clinical differentiation is not a matter of great importance. In general, our experience coincides with that of Graham of the Mayo's clinic at Rochester. Minn who says "Locating an ulcer of the peptic tract from the area of pain as given by the patient is perplexing and often very uncertain. Most of the pain is epigastric, let the lesion be where it may, but the lower the lesion the oftener is the sensation of pain to the right of the median line, and some ulcers, especially the duodenal variety, give characteristic finding. The longer food gives comfort, other things being equal (as duration of time of disease, extent of trouble, obstruction, etc.), the further down is the ulcer situated, so that in duodenal ulcer, especially in the early days of its history, food gives relief for a longer time than when the ulcer is located higher, *i.e.*, in the stomach proper. Following this period of ease the characteristic ulcer symptoms return, of gnawing, boring even to extreme pain, with gas, sour eructation, vomiting of various amounts and intensity, dependent on obstruction and extent of lesion."

I shall note the symptoms in the order of their prominence as we have found them.

(1) *Subjective Symptoms.*

Pain.—This is the most common symptom complained of. The pain described by some authors as "gas pain" varies considerably in character. Patients speak of it as "burning," "twisting," "boring," "gnawing," "dull aching" or "colicky."

In the seventy cases it is recorded "occasional" in five; as "intermittent" or "recurring" in ten; "constant," "severe" or "persistent" in forty-seven; and "agonizing" in eight. The pain in both gastric and duodenal ulcer is usually referred by the patient to the epigastrium and in duodenal cases, it is more likely to be well defined below the right costal arch. In a large proportion of cases it is reflected to the lower dorsal region and occasionally beneath the right scapula, rarely to the scapular region. This reflection of the pain we found most common in duodenal cases, and it was usually present in all cases of marked pyloric stenosis. This dorsal pain varies in severity, we have seen many patients branded in this region (dorsal) for its relief. According to Graham, in gastric ulcer the pain begins shortly after eating and is at its height a couple of hours later. In duodenal cases it begins later and is at its height two to five hours after meals, and this has been our experience. In duodenal ulcer when the pain is more or less constant the patient sometimes finds relief by eating and drinking, the food and drink serving for a time to neutralize the acid acrid gastric secretion, which later irritates the duodenal ulcer and sets up spasm of the duodenum and pylorus, eventuating in the retention of the gas and the distention of the stomach. *Pari passu* with the retention of food due to organic stricture, or pyloric spasm in duodenal ulcer, the stomach distends until relief comes in consequence of the emptying of the organ by reversed peristalsis, vomiting, or voluntary emesis by the use of

the fingers in the throat. Many of these patients spend hours together sitting up at night kneading or rubbing their epigastric region for the relief of the gas pain. Some patients complain of a marked gurgling sensation due to mechanically emptying the stomach on kneading the epigastrium which brings about partial, but seldom complete, relief of the pain. In the early stage of chronic ulcer the stomach relieves itself by voluntary reverse peristalsis, but later as loss of motor power develops the patient is required to use his fingers in his throat to stimulate and hasten emesis, without which he finds little or no relief. Even then the complete emptying of the stomach is not possible without the use of the stomach tube. In some of the early cases of duodenal ulcer we have observed periods varying from several weeks to several months in which there has been comparative freedom from gastric distress. Graham records a similar finding. He says of the significance of pain as a symptom in gastric ulcer. "Pain in gastric ulcer is the most constant symptom and perhaps the most characteristic in its manifestation. Not the kind of pain, not the location of pain, but the time of the pain is the distinguishing feature. It varies from mild distress to that of a great intensity, and unless complications have introduced great modifications its appearance, control and disappearance are almost, if not quite, the final evidence required for a correct diagnosis. The pain appears sometimes after meals; oftener it is as nearly exact to say before meals. Usually in from two to five hours after a hearty meal the burning, gnawing feeling begins, increasing in intensity until vomiting or irrigation has removed the acid offending material. Food eases the pain, the heartier the meal the longer the relief. Specially is this true in the history of duodenal ulcer. Gradually, however, this relief lessens until late in the history and after the patient has been long a 'surgical case,' food eases but little. When complications (perforations, adhesions, obstructions) are far advanced, food gives no ease and distress follows its ingestion. At this stage relief comes only after ridding the stomach of all offending material by irrigation or forced vomiting. The pain comes in definite periods of attack; it occurs daily or two or three times a day during this period; or from two to five hours after meals and is therefore premeal as often as it is aftermeal in time. It is epigastric, radiating seldom to other areas and except in the later stages is relieved in part, at least, by food, drink, alkalies, vomiting and irrigation. The kind of pain depends on the pathological conditions. It may be burning, gnawing, lancinating, boring—cutting (apple core sensation) or the feeling pain of perforation. Most of the ulcers of the stomach and duodenum (and this is true independent of location) have a longer or shorter spell of relief from food, until late in the disease, at which time the early history is necessary both for diagnosis and localization of ulcer. There are to-day clinicians who persist in the idea that if ulcer of the stomach is present food gives immediate pain, or at any rate, no sense of comfort even for a short time. This is not true in the great majority of peptic ulcers, let the lesion be where it may." The foregoing statement by Graham coincides entirely with the writer's personal experience in India with the exception of the radiation of the pain (*vide* supra) which we have found fairly common.

Vomiting.—In fifty-eight cases frequent vomiting was complained of. In six it was recorded as "occasional." Involuntary emesis appears to be most common for some months after the beginning of the dyspeptic symptoms, later it may give place to voluntary emptying of the stomach by the patient in order to obtain relief, meanwhile the power of reverse peristalsis by which involuntary relief attained in the earlier stages is lost, and the patient now gets relief only by the use of his fingers in his throat. In the early stages some patients experience periods of relief from vomiting varying from a few weeks to several months.

Nausea.—Nausea *per se* is not frequent, in only one case was nausea without vomiting complained of. Nausea may therefore be regarded as a negative symptom, when present with vomiting it is seldom complained of.

The character of the vomit varies considerably as vomiting occurs early or later after meals. In gastric ulcer it is more likely to contain quantities of undigested food, especially when stenosis is present. It is difficult, however, to say from the character of the vomit alone as to whether a given case is one of gastric or duodenal ulcer. The vomit in both cases is usually sour, and in duodenal cases it is apt to be acrid acid. It is occasionally foul or even stinking containing sarcinæ in abundance. Frequently it is bile-stained and less frequently contains streaks or small clots of blood. The food returned will be found finely sub-divided or in coarse particles according to the degree of loss of motor power of the stomach. In some cases we have found undigested rice in the lavage water four days after ingestion and patients have complained of vomiting food taken a week previously. In such cases motor power is greatly reduced or stenosis advanced, usually both conditions obtain. In these cases dilatation and thickening of the stomach are usually present.

Stagnation and return food after twelve hours is more pronounced in gastric than in duodenal ulcer though it may be absent entirely in either, and is most commonly absent in duodenal cases. This is what one should expect since stenosis in the duodenum, the result of ulcer, is infrequent as compared with ulcer and stenosis in or near the pylorus.

Constipation.—Constipation was present in 61 cases, many of these patients stated that they seldom had a free motion except by the use of cathartics. Alternating looseness and constipation was complained of in one case. This patient (already referred to as having no palpable lesion) later on developed tuberculosis and may have had tubercular lesions in the bowels at the time of operation. In nine cases no mention is made of this symptom. Constipation, which is relatively uncommon among healthy Indians, may, when it accompanies chronic gastric distress and vomiting, be regarded almost as a pathognomonic sign of gastric and duodenal ulcer.

Anorexia.—Loss or impairment of appetite was present in the majority though it was not generally

complained of to any great extent except in advanced cases. *Fear of eating* was more generally complained of than actual loss of appetite. Many of these patients will confine themselves to one meal a day and frequently go to bed hungry fearing the nocturnal distress and consequent loss of sleep resulting from an evening meal. Flatulence with sour and distressing belching was observed in about two-thirds of the cases.

Loss of weight and strength.—These patients usually complain of progressive loss of flesh. They grow steadily weaker so that in time any kind of labour calling for considerable muscular exertion has to be abandoned. A large proportion present themselves in advanced stages of muscular weakness with wasted, flabby muscles and weak hearts.

Objective symptoms.—Visible peristalsis.—This was observed in thirty-five cases. It was doubtless present in others at times when observation was not possible or convenient. It was observed in twenty-two cases in which pyloric stenosis was made at operation. In 16 duodenal cases in which peristalsis was observed there was no evidence of stenosis, visible muscular activity of the stomach being evidently due to spasm of the pylorus produced by the irritating contents of the stomach upon the duodenal ulcer.

Muscular Rigidity.—Rigidity of the recti muscles was occasionally noticed in cases which at operation proved to be duodenal ulcer. Usually, however, the abdominal muscles were relaxed from continuous massage or kneading of the abdomen. Not unfrequently the abdomen was found scaphoid, though generally the epigastrium presented a full and frequently a bloated appearance if seen several hours after a meal.

Emaciation.—This is noted as "slight" in sixteen; "moderate" in twenty; "marked" in thirty; in several of the last group it might have been called "extreme"; in four cases no mention is made of wasting. Cachexia was occasionally observed in cases of long standing.

Hemorrhage.—Hemorrhage from the stomach was observed while in the hospital in three cases, one of these proved to be cancerous. Of the entire series, as already stated, fifteen cases gave a history of hematemesis and two of melena. In no case, however, was the quantity of blood more than a few drachms so far as we could ascertain from the patients' statements. In a case previously operated on but not reported in this series, death resulted from violent hemorrhage from the stomach and lungs on the 19th day after operation. In about 10 per cent. of this series the lavage water contained streaks or small bright clots of blood induced apparently by the mechanical action of the stomach tube. In view of these findings it may be concluded that gastric *hemorrhage* as a symptom of chronic ulcer of the stomach and duodenum is *not common and in the majority of instances is absent.*

Gastric Analysis.—Owing to the meagreness of our hospital staff and the admission of most of the cases during our busiest operative months, gastric analysis was made in only forty-nine of the cases. In the cases of *gastric ulcer* in which analysis was made free HCl was normal in eight; excessive in seven; diminished in seven and absent in three. In the duodenal cases free HCl was normal in ten; excessive in two; increased in two and absent in one. Lactic acid was present in eleven, eight of which were gastric and three duodenal. All analyses were made after a test meal consisting of ten ounces of unleavened native wheat bread with half a pint of weak tea without milk, or an equal quantity of water, and withdrawn in one hour after ingestion. All of the eighteen cases in which there was diminished free hydrochloric acid the patient gave a history of long standing dyspepsia. Complete absence of HCl was observed in four cases in which at operation no positive evidence of cancer was observed.

Differential Diagnosis.—Inasmuch as chronic gastritis is a disease most frequently mistaken for chronic ulcer of the stomach and duodenum while the treatment of these two conditions differs materially, it is important to distinguish between them. The following is an attempt to classify the principal diagnostic features of each as we have observed them:—

	Chronic Gastritis.	Gastric and Duodenal Ulcer.
Causation ...	Common in alcoholics. Probably less common than ulcer.	Occurs in all classes chiefly those accustomed to coarse highly seasoned food, over-eating.
History ...	Symptoms not constant and relief by diet and medication. Symptoms not progressive.	Attacks intermittent at first, later persistent, diet attended by temporary or no relief. Often history of long standing. Symptoms progressive.
Pain ...	Full heavy sensation in epigastrium, seldom acute pain.	May be intermittent at first, later generally persistent. Often acute severe and even agonizing, relief only by emesis or after hours of suffering. Often referred to dorsal region.
Visible Peristalsis.	Not present as a rule.	Present in most cases and invariable in cases of stenosis.
Gas Distension	Often present ...	Frequently present.
Nausea and Vomiting.	Nausea frequent; vomiting not common.	Nausea not common, vomiting always present at some time or other and persistent in advanced cases.
Hemorrhage...	No history of, as a rule.	Occurs in about twenty-five per cent. of cases.
Loss of weight	Not present ...	Present as a rule, often progressive.
Constipation...	Frequently present.	Present as a rule.

	Chronic Gastritis.	Gastric and Duodenal Ulcer.
Result of Lavage.	No return of food after six to eight hours as a rule.	Return of food after eight to twelve hours and frequently after longer periods.
Acidity ...	Free HCl frequently diminished. Lactic and butyric frequently present. In nervous dyspepsia "Hyperchloridria."	Free HCl occasionally in excess, may be normal, is often diminished. In advanced cases of saddle ulcer or stenosis butyric and acetic acid may be present.

The most dependable signs of gastric and duodenal ulcer are in the order of importance :(1) Gas pain, (2) vomiting, (3) return of food in lavage in eight to twenty-four hours after ingestion, (4) loss of weight, (5) visible peristalsis, (6) constipation, (7) persistency of symptoms. The findings in gastric analysis, in our experience, are not a reliable guide in the diagnosis between gastritis and ulcer though unquestionably of greater value between nervous dyspepsia and ulcer, or cancer and ulcer. Cancer may be, and doubtless often is, mistaken for gastric ulcer: in the former, however, cachexia develops within a few weeks or months of the onset, and the wasting and cachexia are more progressive. The presence of a tumour mass developing within a few months of the onset of symptoms and the absence of hydrochloric acid and the presence of occult blood make the diagnosis of cancer positive. The presence of the Boas-Oppler bacillus is also a valuable aid in the diagnosis of cancer in the absence of a palpable tumour. Ulcer is frequently a disease of years, cancer of months. It is to be remembered, however, that chronic ulcer frequently degenerates into cancer.

The question of Surgical Intervention.—By reason of the wide experience of a large number of well-known operators on both sides of the Atlantic, including Kocher, Mikulicz in Europe, Mayo Robson, Moynihan in England, the Mayo's, Ochsner Murphy and Brewer in America, and the voluminous literature pertaining to gastric surgery now available, the indication for operation in these cases is no longer a matter of indefinite conjecture but can be stated in terms of practical clearness. In the very extensive experience of Mayo's of Rochester Minn. no case of gastric ulcer should be operated on "until he has had nine medical cures." That is to say, no case capable of cure by medication should be subjective to operation. Without doubt many cases of chronic ulcer, especially those in which the ulcer does not invade the pylorus or duodenum and is not producing symptoms of a persistently distressing character, are often sufficiently benefited by lavage, medication and diet to make operation for the time being inadvisable. We believe, however, that there are few such patients who sooner or later will not reach such a stage of suffering and invalidism as to make operation for their permanent relief an urgent necessity. A considerable number of these patients have been admitted into the Miraj Hospital, treated medically and discharged "relieved" or much "improved" and who have been readmitted some months or a year later with their symptoms so exaggerated as to make operation imperative. These cases are so persistently chronic that the continuous use of the stomach tube, regulation of the diet and the use of suitable medication for months if not for years are all demanded if the patient is to remain reasonably comfortable. Obviously it is not possible for the average Indian to persist in this treatment even if he had the patience, persistence and means of carrying it out, which as a rule he has not. One is therefore not surprised when these patients turn up with the history of having run the gauntlet of several dispensaries, native vaids, quacks, conjurers, etc. They have had their "nine cures" and are usually so far advanced in their suffering by the time they get to us that it now-a-days requires but little persuasion to secure their consent to operation when in our judgment this is deemed inadvisable. They frequently demand *immediate* operation in spite of our contrary judgment.

What then are the indications for operation? And having determined to operate what method shall be employed? Brewer of New York after collating his experience in gastroenterostomy arrives at the following conclusions :—

"The indications for treatment in benign lesions of the stomach are :—

First.—Intelligent medical treatment in all primary cases of simple round ulcer. If unrelieved after six weeks of medical treatment operation should be advised.

Second.—Operation in all cases of indurated chronic ulcer and in all cases of recurrent symptoms after a primary cure.

Third.—Operation in all cases of pyloric stenosis excepting those due to gummatous infiltration.

"Undoubtedly the most brilliant results have been obtained in cases of chronic indurated ulcer and benign stenosis of pylorus and this contrasts so strikingly with the almost universal failure which is followed by diatetic and medical treatment of these conditions, that to-day the great majority of intelligent medical practitioners advise operation in those suffering from these lesions."

Moynihan states the conditions calling for gastro-enterostomy as follows :—

"(1) When perforation has occurred in an ulcer so situated that the closure of the opening narrows the outlet of the stomach, *e.g.*, in pyloric ulcer or in duodenal.

(2) When perforation has occurred in an ulcer in the stomach and a second ulcer near the pylorus or in the duodenum is seen. (In one of my cases death occurred from the perforation of a duodenal ulcer eleven days after the closure of a gastric perforation).

(3) When hemorrhage is occurring from a duodenal or gastric ulcer in such quantities as to threaten the life of the patient. In such circumstances the hemorrhage usually occurs in increasing quantity at decreasing intervals.

(4) When inveterate dyspepsia is caused by a chronic ulcer of the stomach which medical treatment has not sufficed to heal.

(5) When an inflammatory tumor of the stomach or pylorus results from the induration and thickening around an ulcer.

(6) When perigastritis with adhesions secondary to ulcer or other complications (cholecyto-gastric or duodenal fistula) is interfering with the proper action of the stomach.

(7) When an ulcer in its cicatrization has caused a narrowing in the body of the stomach (hour-glass stomach) or at the pylorus (pyloric stenosis), with consecutive dilatation and hypertrophy of the stomach behind the obstruction, and stasis of the stomach contents.

(8) When a duodenal ulcer has been diagnosed with certainty, and its symptoms have not rapidly receded under treatment. Medical treatment is of extremely little value in cases of duodenal ulcer owing to the mechanical conditions present. Personally I advise surgical treatment for duodenal ulcer as soon as the diagnosis is assured."

For the average Indian patient we believe that cases with evidence of chronic ulcer which is not benefited after ten days of hospital treatment by lavage, medication and diet, that is to say cases whose symptoms persist in spite of this treatment, and especially those in which food taken at night is persistently returned in the morning wash, should be subjected to abdominal section, and visible evidence of ulcer being found in the stomach or duodenum some form of drainage operation should be performed. I would also include case of long standing gastric distress attended with occasional vomiting and progressive loss of weight even though there is little or no return of food during lavage. Mayo suggests a test for obstruction which consists in the use of raisins in an evening meal. If the skins are returned in lavage on the following morning it is regarded as evidence of obstruction.

As to the second question as to what lesions are best suited for operation, the consensus of opinion of a large number of operators of extensive experience in gastric surgery seems to warrant the conclusion that only cases presenting visible or palpable lesions in the gastric or duodenal walls are proper cases for a drainage operation. There may however be exceptions to this rule, as, for example (Case No. 6116), the case of a girl after weeks after medical treatment in hospital, with symptoms of chronic ulcer, and at operation showed no visible or palpable lesion, was entirely relieved by a posterior gastro-enterostomy. The stomach in this case was abnormally small. Neurasthenic cases in which on opening the abdomen no demonstrable lesion is found should not be subjected to operation. We have had several such cases, one reported in this series and others operated on previously bear out in our experience this contention.

As regards the results of posterior gastroenterostomy we can say that though we have found scarcely any form of surgical that has given us more general satisfaction in the past few years than these operations for gastric and duodenal ulcer, we do not feel quite so enthusiastic as Kocher who says :—" The pain in the stomach disappears immediately after the operation. This is the invariable rule. The patient does not require to pay any further attention to the nature of his food. The vomiting disappears, the bowels become regular, there is a progressive improvement in the process of digestion." Still we believe these results can be achieved in the vast majority of cases of demonstrable ulcer. In pyloric cases the greater the stenosis the prompter and more striking are the operative results. The immediate results of operation is invariably prompt relief of the distressing symptoms. Usually within two weeks these patients are able to take their ordinary food without pain or discomfort.

With regard to the end results we are seldom able to secure reports after the patient leaves the hospital, which, as is the common experience of all Indian surgeons, is a most difficult matter ; indeed it is impossible in the majority of cases to follow them up and secure reliable data as to the final results of our surgical work. For the present then we must rely upon the statistics of Western operators, and, provided we operate for identical conditions and our cases survive operation, we can reasonably expect that the end results in India will be equally satisfactory with those secured in more enlightened communities. Dr. W. J. Mayo in June last reported 379 cases of gastric and duodenal ulcer operated on prior to June 1906 with an operative mortality of 4·8 per cent., 318 of these were demontrable ulcer and of 234 were traced. Of these 80·7 per cent. were cured, 9 were improved, 4·2 per cent. were unimproved. Up to June, 1908, the Mayo's report is over 300 gastroenterostomies by the " no loop " method with an operative mortality of less than 1 per cent. Moynihan and Mayo Robson of Leeds report similar end results. The former in May last reported 174 operations for gastric and duodenal ulcer with two operative deaths. While operators of less experience may not be able to report so low an operative mortality, still in the hands of the average surgeon of any considerable experience in abdominal surgery the " no loop " operation as now usually performed ought not to be attended with an operative mortality of more than four to six per cent. In India we can scarcely expect the well nigh perfect results now achieved in European and American hospitals since we have to deal generally with a much more ignorant and refractory class of patients, many of whom also only apply for surgical treatment in a condition of extreme weakness and emaciation. Yet in spite of these drawbacks the immediate relief is usually so prompt and satisfactory as to warrant operation notwithstanding the greater average mortality inevitable in India, bearing in mind the large percentage who probably ultimately die of cancer engrafted on the ulcer.

Mortality.

In the seventy operated cases under report there were seven deaths, 10 per cent. 5 of these deaths were due to pneumonia ; one to toxæmia ; and one in a patient otherwise doing well but who persisted in getting out of bed and on the third day walked the length of a long ward and died suddenly of heart failure on return to his bed.

Post operative pneumonia is well known to occur more frequently in operation in proximity to the diaphragm than in other parts of the abdomen, and in our experience Indians are specially susceptible to this complication. Four of the five deaths from this cause occurred in the first 26 of the series. We have, we believe, avoided this complication of late in several cases by placing the patient in the Fowler (semi-sitting) position as soon as he recovers from the effect of the anæsthetic, by the use of cotton wool and flannel jackets, and a special room for the patients during the first twenty-four hours, maintaining a temperature of 80 to 85 degrees and avoiding the drafts of an open ward. The hypodermic use of quinine on the first appearance of chest complications has also promoted the clearing up of chest symptoms and in several instances appeared to abort the pneumonic process when undoubted symptoms of this complication were both present and progressive. We have also found it necessary to administer heart stimulants hypodermically for two or three days following operation in badly debilitated patients.

The death from toxemia abovementioned is of special interest with reference to the use of the saline enemata. This patient, a young man of 20 and in fair health, a case of pyloric ulcer with stenosis and adhesions. The operation was satisfactory and there was no operative shock. An enema of 40 ounces of half strength normal salt solution was given after operation, and 30 ounces repeated 4 hours later in accordance with our practice for some time previously. Soon after the second enema the patient became delirious, and later comatose, from which he recovered in about four hours. His pulse during this time was full and of high tension. His temperature rose *pari passu* with the onset of these symptoms and continued high after the subsidence of the coma. He continued highly toxic and died on the fourth day. The examination of his urine prior to operation was negative. There was no evidence at any time of abdominal infection, his abdomen was soft and painless except for the usual wound tenderness. Post mortem was not permitted. Excluding this case and the case of death from heart failure above referred to, the last 35 cases were without mortality.*

As to the immediate results of operation, excluding the fatal cases, 60 were entirely relieved of their symptoms and were able to take their ordinary food without pain or discomfort before leaving the hospital. Two experienced slight pain and biliousness. One case—a patient—with saddle ulcer and stenosis, heard of several months after leaving the hospital, complained of occasional attacks of bilious vomiting. Another without demonstrable lesion was relieved to some extent, but some months later developed tuberculosis.

What Form of Operation should be performed ?

The present day opinion of most experienced surgeons in gastric surgery appears to be (1) Posterior gastroenterostomy without a loop, the opening being at the most dependent part of the stomach, the duodeno-jejunal flexure is the operation of choice, the operation being preferably done by suture. (2) In cases of stenosis with a freely movable pylorus, dilatation and gastrotosis being absent, pyloroplasty after the method of Finney may be preferred, though the results appear to be generally little if any better in these than those following gastroenterostomy and is usually more difficult to perform. The Finney operation in principle however should be best suited for cases with freely movable pylorus and the ulcer area situated in the pylorus. The writer's experience consists of but one such operation which was not satisfactory, due probably to faulty technique.

In a certain proportion of cases of indurated ulcer, excision of the ulcer area is considered the proper procedure by an increasing number of surgeons. The cases most suitable for this method are those of ulcer on the more occasional portions of the stomach and the organ freely movable and adhesions scant or absent. The mortality, however, is still higher than that of gastroenterostomy and it is still an unsettled question as to whether all in all the end results justify the more serious operations of excision. The possibility of cancer being engrafted on the ulcer is of course the chief argument in favor of excision. Gastroenterostomy, however, secures cicatrization of the ulcer and thus prevents the development of cancer in the majority of cases where this might otherwise supervene.

We have a number of times done with satisfaction an anterior gastroenterostomy with an 18-inch loop using a Murphy button as suggested by Mayo. This operation we reserve for badly debilitated subjects with excessive dilatation of the stomach and in which a rapid operation is a prime consideration. This operation is easily accomplished within 20 minutes.

The operation we now invariably employ is that performed by Moynihan slightly modified by Mayo and to which we have added a further minor modification and is performed as follows :—

Only sterilized food should be allowed for two days preceding operation and oral antisepsis employed. On the day previous to operation two ounces of Castor oil is given, followed by a high cathartic enema and low soap and water enema on the morning of the operation. Two hours before operation copious gastric lavage is performed and the mouth thoroughly cleansed and antisepticized before the administration of the anæsthesia. We prefer ether as an anæsthetic. The abdomen is opened by an incision through the right rectus three-fourths of an inch from the median line with its lowest point half an inch above the level of the umbilicus. The stomach and colon are drawn into the wound and turned up over the epigastrium. The jejunum is sought and the first few inches drawn into the lower part of the wound. An opening, two inches in length, is now made bluntly through the mesocolon to within an inch of the mesenteric attachment to the colon between the mesenteric vessels. This opening is made vertically on a line corresponding to the left border of the spinal column. The posterior wall of the stomach, or that portion of it lying behind the

* In 1908 we had 47 gastroenterostomies with two deaths, since then we have done 15 without mortality making 62 consecutive cases with 2 deaths.

opening made in the mesentery, is drawn into the opeinng and the upper blade of the three-bladed intestinal clamp, (the blades covered with rubber tubing) is applied, taking in its grip fully three inches of stomach in a direction downward from right to left (Mayo) or vertically (Moynihan). The jejunum is now drawn out and to the left its duodeno-jejunal junction made taut and if the peritoneal fold at this point (ligament of Trietz) is long it is snipped for an inch or two so as to liberate the jejunum a little higher up, thus bringing the stoma nearer the termination of the duodenum. The bowel is now drawn into the remaining blades clamped longitudinally for three inches being careful to avoid the mesenteric border in the grip. The proximal end of the clamp should grip the bowel as near to the beginning of the duodenum as possible without undue traction so as to avoid a jejunal loop. The clamp in place the colon is replaced within the abdomen above the stomach and all of the stomach and bowel reduced save the portions within the clamp. The abdominal wound and the abdominal cavity are now protected with moist gauze pads around and beneath the clamps. Beginning at the right the stomach and bowel, held in opposition by the clamp, are united by a running stitch of fine celluloid thread on a round pointed straight needle (leaving four inches of one end free after tying the first knot) taking in peritoneum and muscle and tied at the left limit of the structures between the clamps. This suture is left long and covered by a sponge gauze. An incision is now made in the stomach two-and-a-half to three inches in length parallel with the line of sutures and one-quarter inch from the same, escaping blood is sponged away and the protruding gastric mucosa on the upper lip of the wound trimmed off to within a quarter of an inch of the musculosa and to within half an inch of each extremity of the incision. The stomach is similarly incised but no mucosa removed. Beginning again at the right a continuous button hole through and through suture of No. 2 iodine catgut (some operators prefer chromicized gut but we have not found it necessary) unites finally the posterior edges of the stomach and bowel constituting the inner posterior suture. Having reached the left extremity of the wound this same suture is reversed coming back to the right by a through and through Conell suture (taking the place of the button hole stitch posteriorly) to the right angle of the opening and closing the anterior wall of the stoma. This is the anterior inner suture. The site of the suturing is now cleansed with moist gauze sponges, the unused thread suture is now continued from left to right closing the peritoneum over the anterior through and through (inner) catgut suture. The musculosa is taken in this suture as in the preliminary posterior suture, and is finally tied to the short end left at the original insertion. This completes the anastomosis. The area is again cleansed protecting sponges removed and the split margin of the mesentery is attached to the bowel throughout most of its length close to the suture line which it covers and protects using four or five interrupted sutures of fine catgut or celluloid thread on a rounded pointed curved intestinal needle. At the left extremity of the stoma, for a distance of half an inch, the split mesenteric margin is *attached to the stomach instead of the bowel.* This is to avoid the bowel slipping up through the slit in the mesentery and causing a kink which happened in one of our cases requiring opening and liberation of the bowel at that point.

The organs are now replaced and the abdomen closed by tier suture of peritoneum, muscle, sheath and skin. Catgut is used in all but the skin, and for this we employ silkworm gut. Two extra relaxation sutures entering three-quarters of an inch from the skin margin and going beneath the rectus muscle and left untied until the closure of the skin incision when they are tied over pad of gauze are used to prevent displacement of the dressing and the separation of the wound should the patient get out of bed. These two sutures are put in after sutures of the peritoneum. The first dressing is done on the eighth day when the stitches are removed.

A saline enema of forty ounces of half strength salt solution is given on returning to bed, thirty ounces more at six hours intervals during the following night. Hot water by the mouth, one ounce every hour, if the patient is thirsty, which as a rule he is not, is allowed during the first twenty-four hours. On the second day two ounces of Mellin's Food every three hours is allowed and increased one ounce at each daily feeding for three days when milk is given for two days, conjee and milk for two or three days more, after which rice is allowed, and by the tenth day ordinary diet. Rectal feeding is rarely necessary. There is frequently 2 or 4 degrees of fever for two to four days following the operation, and if accompanied by chest symptoms the patient is given an hypodermic injection of quinine ten to fifteen grains every four to six hours with appropriate heart stimulants in debilitated patients. The patients are out of bed as a rule by the fifteenth day and discharged within three weeks as a rule.

DISCUSSION.

Mr. Kulkerne mentioned a case which showed signs of much relief from the symptoms which much resembled those of gastric ulcer as mentioned in the paper of Dr. Wanless after taking a morning draught of common salt in water, which he said was rather strange, as the salt was rather likely to increase the HCl of the gastric juice and so aggravate the symptoms.

Dr. J. V. Campbell, M.A., M.B. (Jammalamadugu).—We meet with a considerable number of cases who would need for their relief gastro-enterostomy. Yet usually such patients will not consent to an operation. I have done it only 3 times. I did it without a clamp. If they are a source of danger, we can therefore dispense with them. We must all congratulate Dr. Wanless on his splendid results.

Col. Roberts :—The pneumonia in Dr. Wanless's cases was, I think, due to thrombosis excited by the clamp. To finish the operation rapidly, a single row of sutures (through peritoneum and muscle tissue) will suffice in case of the stomach.

Major H. Smith.—I quite agree with Dr. Wanless that this condition is much commoner than is generally thought. He deserves great credit for having brought to the notice of the Profession in India the prevalence of this condition. I do not agree with Col. Roberts that this operation is better done without clamps. Rubber-covered clamps do no harm and they enable us to get through the operation much more rapidly than would otherwise be the case. We must not forget that in this as in other abdominal operations the death-rate has a distinct relation to the time spent under anæsthesia, other things being equal.

Major A. Street.—I have rarely an opportunity of seeing the disease in Bombay, either because patients do not turn up, or it is not diagnosed. I cannot understand how an embolus in a gastric vessel can reach the lung, as it has to traverse the liver, and so be a cause of pneumonia.

Reply:—In gastric ulcer HCl is not always increased, and frequently is less than normal. As to what cases are suitable for operation, to speak in general, I would say that no case should be subjected to a gastro-enterostomy when upon opening the abdomen demonstrable evidence of ulcer in the pyloric end or in the duodenum is not present. The one exception I would make to this is that of generally contracted stomach. As regards adhesions getting formed with the parietal peritoneum, it is not likely as the colon and mesocolon lies between. A stomach tube is of greater help in diagnosis than gastric analysis; and the diagnosis thus made by us was wrong in 2 cases only out of 70. As to willingness of patients to submit to operation, I daresay that if we show them the good results in some cases, they will surely come to us and even beg to be operated on. As regards pneumonia, I think the cause was more in the "after treatment." Recently, by excluding cold air, and with Fowler's position for 3—4 days I have excluded the complication. When the blades of a clamp are guarded by rubber tubing, the clamp becomes a great help, preventing bleeding and soiling of the operation part. They enable one to do the operation outside of the abdomen. In fact they are now used by the best known operators.

OPERATION FOR ELEPHANTIASIS OF SCROTUM.

By Major GABBETT.

The patient should be kept under observation in the ward for not less than a week. During this period a careful examination is made of his general health, daily temperatures and the condition of his urine should be specially noted. It is of great importance that any symptoms pointing to the existence of a urethral stricture should be detected, as its presence might lead to great difficulty in relieving the retention of urine which almost inevitably follows the operation.

An examination should also be made for hernia which may be present in the neck of the tumour.

The penis is usually deeply buried in the scrotum so that no sound can be passed beforehand, but should there be any difficulty in passing urine it would be advisable to divide the operation into two stages, first enucleating the penis and dilating the stricture and subsequently removing the scrotum.

Dermatitis and scabies are local conditions frequently met with which require prolonged treatment before the patient can be considered fit for operation. The rugose condition of the skin necessitates very special efforts to obtain cleanliness. Three or four hot baths, thorough scrubbing with soft soap and a soft nail brush and daily packing with wet antiseptic gauze are indispensable preliminary measures during the week he is under observation.

Anœsthesia.—I strongly recommend the use of spinal injection in these cases. The shock which may follow the removal of such a large mass is apparently abolished.

Operation.—The patient is placed in the lithotomy position,[1] for the final scrubbing with sterile water and spirit soap followed by antiseptic douching. The operation area is surrounded by dry sterilized towels, taking special care to clip them tightly over the feet.

A three-inch incision is made from the pubes to the opening in the tumour from which the urine escapes. This is rapidly deepened with the scalpel until the fingers can feel and pick up the firm body of the penis sometimes lying as much as 2 inches deep in the œdematous blubbery tissue. The mass of smegma usually found in the prepuce should be carefully wiped away. The penis is now enucleated as far downwards as possible and to its suspensory ligament above, by the use of the fingers and successive snips of the scissors. A fringe of apparently healthy prepuce will be found which looks as if it might be useful to cover in part of the raw surface of the body of the penis; this fringe should, however, be removed completely, as, if left, it will subsequently form hypertrophied tags and lumps. A sound should now be passed to ascertain the viability of the urethra. There is often troublesome oozing from the neighbourhood of the frænum which is best controlled by underrunning with a couple of fine catgut sutures. Any other bleeding points on the penis are stopped if possible by forcipressure—since tying or twisting them would leave knobs which would interfere with the subsequent close fitting of skin grafts. If necessary the forceps may be left on while the penis is wrapped in a small sterile towel and held up out of the way while the rest of the operation is being completed.

The incision is then prolonged downwards along the raphé sufficiently far to enable the testicles to be enucleated. From each half in turn the testicle and cord is shelled out of the blubbery tissue in which it lies in much the same way as the kidney can be enucleated from the peri-renal fat—chiefly by the use of the fingers. A firm fibrous attachment below may require division with the scissors. Any fragments of tissue adherent to the tunic are stripped away. It is usual to find one or both tunics distended with hydrocele fluid—sometimes to a very large amount. If this is the case a short incision $1\frac{1}{2}$—2 inches in length is made near the neck of the pyriform tumour, the fluid evacuated and the testicle everted through the incision. This can be done very rapidly without the division of a single vessel. The collapsed tunic fits closely round the back of the testicle and occupies surprisingly little space—but should it be

[1] *Vide* Photo No. 1.

thickened or unduly redundant[1] partial or total excision may be resorted to instead of eversion. Excision of the sac necessitates the ligature of bleeding points and occupies very much longer time than eversion. It has the further disadvantage that subsequent oozing from the cut edges of the tunic will sometimes take place and distending the flaps lead to much trouble and possible suppuration.

If hæmatocele is present, castration without opening the sac is often the best procedure unless the sac be so thin walled as to permit of eversion like an ordinary hydrocele after evacuation and cleaning as far as possible.

Hæmatocele.—I do not recommend excision of the sac in a thick walled hæmatocele—the oozing is extremely difficult to stop and likely to recur and much valuable time will have to be spent in the effort while the grumous contents of the sac will foul the whole of the operation area. In an old standing thick walled hæmatocele the testicle is often atrophied.

The testicles with their elongated cords are now wrapped in small sterile towels and laid up on the abdomen.

The whole of this procedure so far has been accompanied by very little loss of blood and any bleeding vessels can be easily caught in forceps or oozing controlled by large sponge pads pressed into the cavities left by enucleation. The median incision is now prolonged along the raphé until healthy tissue is reached in the perineum, and rapidly deepened until the scrotum can be divided into two halves. A superficial semi-circular incision joining the two ends of the vertical incision is then carried from the pubes round the base of one half of the scrotum keeping well within the healthy skin which will be found to cover the neck of the tumour—dragged there from the thighs and perineum by the weight of the dependent mass. Some large superficial veins are divided by this incision but are easily caught by forceps.

A little cuff of skin and superficial tissue is easily stripped back from the tumour for an inch or so towards the thighs and perineum.

The raw neck so exposed is clamped from above downwards by a large pair of broad ligament forceps or two pairs may be used if one pair is not large enough to grasp the whole breadth of the neck, care should be taken that the urethra and cords are not included. One half of the scrotum can now be removed by cutting through the neck $\frac{3}{4}''$ inch beyond the clamp.[2] The clamp is gradually loosened and the chief bleeding points can usually be seized before they have escaped from the loosened grasp of the clamp.

The other half of the scrotum can then be amputated in the same manner.

[1] *Vide* Photo No. 2. The left T. vaginalis was distended by an unusually large hydrocele and the redundant sac was cut away. Note the long cord. The right T. V. was also distended by a smaller hydrocele and is held up prior to incision and eversion.

[2] *Vide* Photo No. 3. One half of the scrotum has been amputated and the stump is still grasped by the forceps. The remaining half of the scrotum is seen grasped by the forceps prior to amputation.

As the diminutive flaps are not big enough to cover in the testicles the skin of the perineum and thighs is now undermined for a sufficient distance by the use of the scissors and fingers until pockets are formed in which the testicles can be placed.[3] This undermining can be performed with the same ease with which the tissues of the chest can be undercut to cover in a raw area left by excision of a breast. It is sometimes advisable to anchor the testicles by catgut suture to the bottom of the pouches, to prevent a tendency to upride on to the groins but this is not usually necessary.

The flaps should meet over the testicles without tension, if they will not do so the skin must be further undermined. The edges of the wound are now united in the middle line above and below the penis by silkworm gut sutures. A short drainage tube may be stitched between the flaps and removed in 48 hours but this is not always necessary if there is no oozing and no pockets are left. The two stitches immediately above and below the penis should take a good hold of its superficial tissues while it is held well up on the stretch so that any tendency to recession may be prevented. A good sized penis will certainly be one of the marks of a successful operation in the opinion of the patient.

A piece of wet antiseptic gauze is now laid over the line of suture and the patient allowed to move to the middle of the table and resume the ordinary recumbent attitude. The bandages are now cut away from the thigh (which should have been scrubbed and packed the night before) and the skin of the outer side sponge rubbed with sterile water to remove any traces of antiseptic.

With a well-moistened grafting razor, three grafts, the length of the penis and as broad as possible, are taken from the outer side of the thigh, the skin of which is kept evenly stretched between the left hand of the operator and an assistant's hand. Each graft as it is cut is placed lengthways on the raw surface of the penis which an assistant keeps well stretched by traction on a pair of forceps clipped on its fraenum.

The grafts are there carefully straightened by the use of a probe and a pair of forceps and may be fixed to the penis above and below by one or two stitches of fine catgut.[4]

Care should be taken that the edges are not left unrolled anywhere. If the penis is slender and the grafts are cut sufficiently broad, two may be enough to cover in all the raw surface. The grafts are covered by two or more strips of perforated metal foil which have been boiled. These are cut just long enough for the ends to slightly overlap when wrapped transversely round the penis.

A narrow sterilized gauze bandage is now wound carefully round the penis still held well on the stretch commencing loosely so as not to drag on or twist the underlying grafts and gradually tightening as a hold is

[3] *Vide* Photo No. 4. The pocket is shown ready for the reception of the left testicle.

[4] *Vide* Photo No. 5. The 1st graft is shown in position fixed above by a catgut stitch.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1.—Ready for operation.

Fig. 2.—Median incision. Penis and Testicles nucleated and held up. Left T. V. removed. Small hydrocele on right side, left intact.

Fig. 3.—One half scrotum removed. Stump still grasped by forceps. Neck of remaining half grasped by forceps ready for amputation. Testicles and penis held up out of the way by one hand. The other hand retracts the small cuff of healthy skin dissected back from the neck of the tumour.

Fig. 4.—The pocket is shown ready for the reception of the left testicle.

Fig. 5.—First skin graft applied.

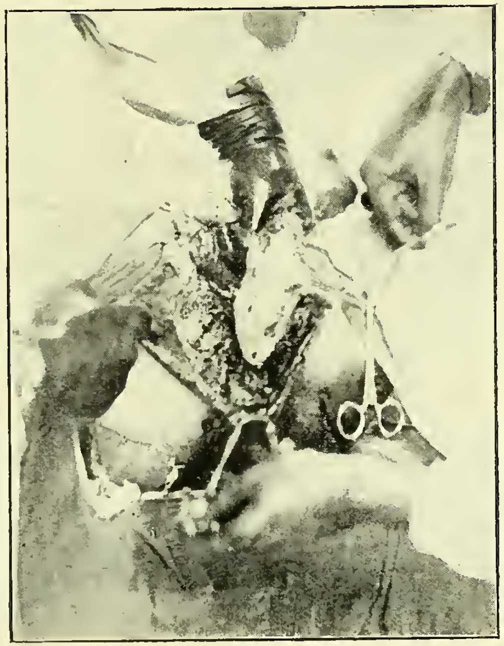
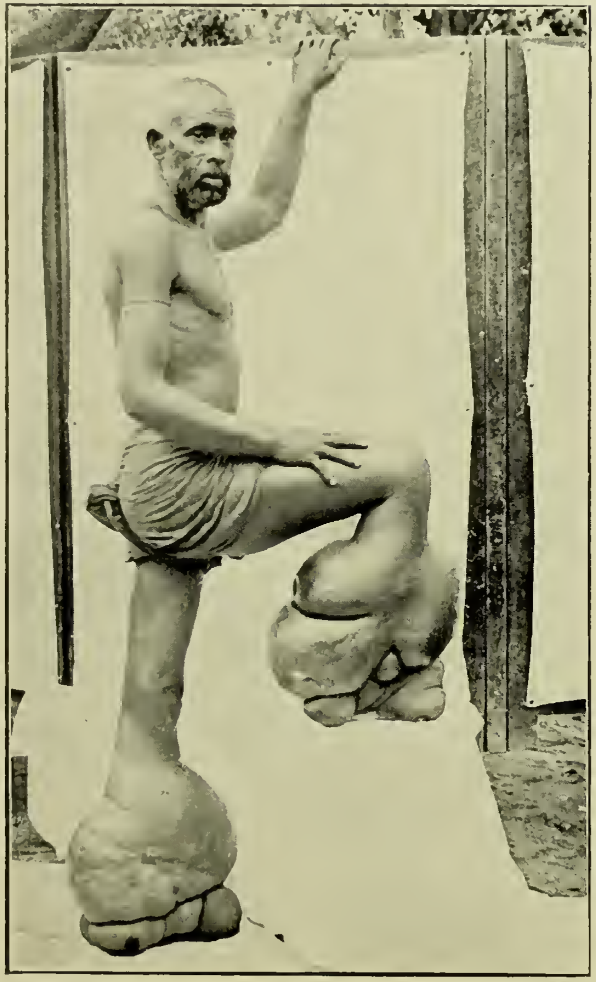
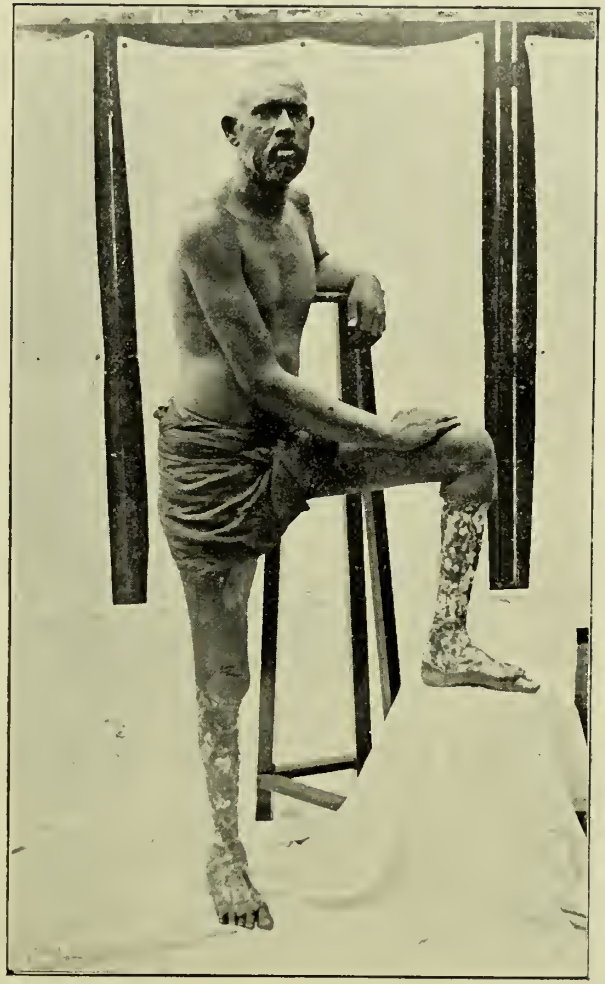


Fig. 4.

Fig. 5.

Operation for Elephantiasis of the Legs.





secured. A few turns of cotton thread will finally secure the edges of the bandage.

The raw surface from which the grafts were taken should be dressed with lint soaked in saturated picric acid solution which may be left on for ten days or longer until the new epithelium has grown.

An antiseptic dressing is now placed on the perineum and bandaged on by a figure of eight—the turns crossing over the perineum.

After treatment.—If a drainage tube has been inserted it may be removed in 48 hours and the dressings changed, otherwise the perineal dressings often do not require changing till the 10th day when the sutures are removed. There will usually be retention of urine which may continue for as long as a week but usually ceases when the bowels are opened on the 3rd or 4th day. Periodical catheterization with carefully sterilized soft rubber catheters should in any case be resorted to for the first four days even if there is no retention in order to avoid dribbling from the meatus which would soak the dressings on the penis and might prevent the skin-grafts from taking.

The dressings on the penis should not be removed for four days—if they remain dry and free from smell they may be left on for a week. They should be very carefully cut and unrolled to avoid disturbing the grafts and a second dressing of either perforated thin gutta percha tissue or metal foil bandaged on with a sterilized gauze bandage as before.

When this is removed some four days later the grafts will be found to have taken firmly. There are sure to be one or two raw patches especially at the base of the penis where the grafts have slipped which will take a long time to heal. These may be dressed with zinc ointment, but need not prevent the patient from getting up as soon as the perineal wound is sufficiently strong.

Patients are very well satisfied with the after-result so I presume the skin-grafted penis proves to be a serviceable organ though I have never made any detailed enquiries.

Convalescence is not always uninterrupted as it is impossible to make the area of operation quite aseptic and suppuration is sure to occur in a varying proportion of cases. In my experience it is always quite localized and the removal of the stitch or a small incision has quickly ended the trouble. A moderate rise of temperature for the first two days is only to be expected and does not necessarily indicate suppuration—it usually ends with the administration of a purgative. If it still continues to rise the dressings must be removed for investigation.

A sudden rise of temperature during convalescence may sometimes be fairly attributed to filarial fever if there is no local evidence of suppuration or any other evident cause.

The largest scrotum removed in Madras weighed 130 lbs. The operation was successfully performed by Surgeon-Major Browne (now Surgeon-General) in 1887 and is recorded in the Proceedings of the South Indian Branch. It weighed more than one half of the total body weight. The record weight is probably that mentioned without further details in Manson's Tropical diseases—224 lbs.

Tumours equal to 1/3 of the patient's weight are fairly common or used to be until the operation became popular.

The operation is tedious and tiring even in practised hands but is remarkably free from danger. It is possible that hernia, hydrocele and hæmatocele may all be found in one operation on an elephantiasis of scrotum.

If hernia is diagnosed beforehand it is generally advisable to cure it by a preliminary operation through the usual incision above P.——ligament.

The chief danger in the removal of large tumours is from shock, and all the ordinary precautions should be taken against shock, but I feel sure that the use of lumbar anæsthesia will do a great deal to abolish this danger.

A good deal of blood appears to be lost but much of it is really mixed with serous exudation from the blubbery tissue and if the incisions are kept in the middle line and bleeding points caught as quickly as possible the loss is never serious. I do not advise the use of a rubber tourniquet even for the largest tumours – it is difficult to apply properly; if it slips, as the best applied tournique may at times, it leads to great confusion and loss of blood and lastly its use certainly causes subsequent oozing.

NOTES ON SPINAL ANÆSTHESIA.

I do not propose to enter into a discussion as to the comparative advantages and disadvantages of spinal anæsthesia nor into details of technique, but to draw attention to a few points in which the method will be found specially useful in India.

It is not likely that spinal anæsthesia will ever replace chloroform for ordinary operations in India, because deaths from chloroform for some reason are very rare in this country—although in England deaths under chloroform are sufficiently frequent to make some safer method of anæsthesia very desirable. I do not say that spinal anæsthesia is safer than chloroform, even judged by European statistics—probably the contrary—but in India the mortality from chloroform is so extremely small that it is unlikely that any other method could rival it in this respect. In other respects spinal anæsthesia has several special advantages in India.

In the first place I have found that many natives have a great objection to chloroform, not on account of its effects, but because they cannot make up their minds to trust the surgeon. If they are to be rendered unconscious for an hour or more, away from all friends and relations, who knows what may be done to them. Instead of an abscess being opened they may awake to find themselves minus a limb, or instead of curing a hydrocele the surgeon may take away their testicles. This vague dread is, I feel sure, one of the reasons which induces the ignorant native to put off operation as long as possible. In my small experience of spinal anæsthe-

sia I have met with three cases in which the patient had previously had chloroform and all three strongly expressed their preference for a method of spinal anæsthesia.

Contrast the moral effect on the rest of the ward of the return of patients from the theatre after operation; instead of being lifted on to their beds from the stretcher like so many corpses and awaking to fill the air with their groans and moans—the spinal anæsthesia case arrives conscious, free from pain and often able to sit up and relate his experiences to his friends. All these subjective advantages weigh more perhaps in India than they do in Europe where there is more faith, less fear and the present is not allowed to entirely obscure the future.

2. A very large proportion of operations in Madras, such as for hydroceles, hernias and elephantiases of the scrotum are performed below the belt. These are exactly the cases for which spinal anæsthesia is suitable. There is no necessity for large doses and it is very rare for anæsthesia to fail to reach at least to the level of the pubes.

3. In two external urethrotomy operations for impassable stricture with multiple fistulæ—a condition far more commonly met with in India than in England—the patients have been able to pass urine when asked to do so. Those of us who have spent many a wearisome quarter of an hour in patient (or impatient) search for the urethra in a rigid watering pot perineum, will appreciate the advantage that is gained by this possibility.

A further advantage of this method for India is the possibility of performing operations without the aid of an anæsthetist. The equipment is easily packed and carried so that an emergency operation could be performed single-handed while travelling in the district or on active service where the services of an anæsthetist might not be readily available.

OPERATION FOR ELEPHANTIASIS OF THE LEGS.

Operated by Capt. Browne, I.M.S., General Hospita , Madras.

I append a photograph of a case before and after operation. At first sight this would seem to be a most successful operation but it must be judged by its results two or three years afterwards.

I have now seen four old cases within three years from the date of operation.

In only one case was the patient at all satisfied with the result. In the other three the operation was a failure, and one patient has since had his leg amputated at his own request because he could not stand the stink from it.

In the first place the gradual contraction of the enormous scar binds down all the muscles and tendons and makes the leg very stiff and useless. Secondly there is a tendency to recurrence. The badly nourished skin thickens, cracks and ulcerates and if neglected a very foul, intractable dermatitis results.

During the periodical attacks of lymphangitis the leg tries to swell but being bound down by scar tissue cannot do so and the tension causes great pain.

If the operation is ever performed those cases should be selected which do not suffer from recurrent lymphangitis.

It is wonderful what useful and active members even the largest elephant legs may be in spite of their weight, and from the few after results I have seen I do not consider that their usefulness is likely to be increased by operation, while usually it is greatly diminished.

The operation is therefore rarely justifiable.

Tumour of Retained Testis.

No. 1134.—Tumour Testis removed by operation by Major Gabbett, I.M.S., from an European, aged 36, born in India.

The left testis became fixed in the inguinal canal when he was a child. For the past two and half years the testis had been gradually increasing in size; pain had only been noticed for two months.

The tumour was soft encapsuled egg-shaped, about 6 inches in length, not very vascular, and not adherent to the surrounding parts.

The section shows large oblong ovate cells, with large oval nucleus and granular well defined protoplasm, often arranged in columns; scattered among them are irregular masses of pale staining homogeneous protoplasm containing several small round clear nuclei; there is little intercellular tissue. Sections cut from various parts of the tumour showed the same structure. Nowhere could normal testis tissue be found.

The appearances are somewhat suggestive of Deciduoma Malignum.

Tumour of Forehead removed by Captain F. Hingston, I. M. S.

No. 1138.—Growth from forehead of a child aged $1\frac{1}{2}$ years said to be of about two months duration, growing rather rapidly and infiltrating the frontalis muscle. The growth was very adherent to the surrounding tissues. Section shows masses of material staining somewhat like colloid material, which in some places shows the remains of epithelial cells and in others is infiltrated with round cells and connective tissue corpuscles. These masses are situated in loose connective tissue containing striated muscle fibres and some elastic fibres. It is suggested that it is of a dermoid nature.

Peculiar Sarcoma of the Kidney.

No. 1182.—Removed by Captain R. D. Willcocks, I.M.S., from an European aged 56.

Intermittent Hæmaturia of 8 years' duration which became very severe 14 days before operation. Loss of flesh for last 6 months. The presence of the tumour was unknown until he was examined in hospital. The urine contained blood and cells described as small spindle-shaped nucleated cells. He died suddenly three days after the operation when apparently he was doing well. *Post mortem* examination was not allowed. The tumour was about the size of a small cocoanut with a definite capsule, and a smooth surface which was slightly lobulated.

On section it was found to consist of very soft tissue presenting a close resemblance to brain matter, in which were strands of denser tissue, and which contained numerous irregular cyst cavities containing turbid mucilaginous fluid. There was a compressed piece of kidney substance covering the upper end of the tumour and incorporated with it at its edges.

The suprarenal body could not be found. The section shows irregularly arranged strands of fibrous tissue, which divide up into finer strands separating groups and columns of fairly large cells consisting of clear or slightly granular protoplasm and containing a small clear round or oval nucleus. The arrangement of the cells and interstitial tissue presented a close resemblance to the arrangement of the cortex of the suprarenal body.

Acute Yellow Atrophy?

No. 1184—Liver.

1. Obtained *post mortem* by Captain J. P. Cameron, I.M.S., from a convict Hindu aged about 29.

The man died after an illness lasting 20 days characterised by jaundice, œdema of the feet and vomiting of bile-stained fluid; general anæmia and ascites with albumen in the urine gradually appeared, and he died in a comatose condition with dilated pupils.

2. At the *post mortem* in the rectum and sigmoid flexure there was a very superficial black adherent membrane, and the whole of the mucous membrane of the large intestine was in a condition of subacute catarrh.

Liver, weight 35 oz., appeared to be somewhat enlarged, and on section showed a mottling of deep red hæmorrhagic and yellow bile-stained areas.

3. An hospital assistant who assisted at the *post mortem* died 6 days later of acute septicæmia apparently contracted through a small wound of the hand, only slight fatty degeneration of the liver was present. A convict warder who also assisted at the *post mortem* is still under treatment for febrile condition accompanied at first by enlargement of lymphatic glands in both axillæ accompanied by vomiting.

4. The section shows that in many places the liver cells have completely disappeared and been replaced by hæmorrhage. Almost all the liver cells remaining are in various stages of degeneration and destruction.

There is a little commencing proliferation of the bile duct cells. The kidneys showed a granular exudation into the malpighian capsules, but otherwise are practically normal.

ABDOMINAL SURGERY.

WITH SPECIAL REFERENCE TO HERNIA.

By Major V. B. BENNET, F.R.C.S., I.M.S.

On thinking over this subject of General Surgery in India, it at once became evident that the aspect of it which above all needed emphasizing was the difference between the results of any operation done in an early stage of the disease and those when the same operation has to be done later on. I consider that the want of this knowledge among the public does more to cause unsuccessful results than everything else put together.

The public are too prone to take time in talking over the subject with relatives or in trying the treatment of the local *hakim* or quack, so that valuable time is lost before the case comes under the surgeon's charge.

Even in the more simple cases such as fractures, dislocations, &c., the result of this is often serious. Fractures which at first we could easily put in position, so that the patient would recover with a good limb, only come weeks later with the bones joined together in a deformed position, and frequently as a result, the patient who refuses to undergo the cutting operation now necessary to remedy matters, spends the rest of his life a cripple, instead of, after a short rest, being restored to perfect vigour.

At one station at which I spent a year the result was even worse. The local custom was to go to the potter for treatment of a broken bone, who potted the part in a clay cast. During that year I had to amputate seven limbs, which were only brought to hospital when they had become gangrenous, as a result of this treatment of simple fracture. Another case that comes to my recollection was that of a man who from childhood had a dermoid tumour under his scalp. When he came for operation at the age of 40, this had grown to an immense size and had so stretched his scalp that it hung like a huge bag nearly down to his waist. He certainly recovered perfectly after its removal, but only after a severe operation instead of the simple and trivial one it would have been in childhood, and in addition he had put up with the inconvenience of this steadily increasing tumour for many years till its presence had become unbearable.

As a last illustration we may take Madura foot. I have had to remove many feet for this disease from patients who have suffered from it from five to ten years. They have put up with the pain and discomfort of this disease for years, only to lose their limb at the end, when an early operation would not only have saved them from these years of suffering, but have left them with a sound limb. The evil result is even more far-reaching than this. The patient goes back to his home without his leg, and his neighbours do not realize that the loss of his limb is not due so much to the actual disease as to the delay in getting an operation done · and, in consequence, when they

suffer from the same complaint, they think the only cure is amputation of the foot, and so they likewise postpone the evil day as long as possible. The danger of this delay becomes much more serious when we come to lesions in the abdominal cavity.

Take the more chronic cases such as the growth of an ovarian tumour. The number of deaths after this operation in England is often less than one in a hundred, but it is not so in this country. How frequently we have to operate on a woman, as the only way of saving her life, who has struggled along for months with increasing swelling of the abdomen and failure of health from pressure of the tumour on bowels, heart and lungs, and who only submits to operation when on the point of death. Though, even so, the surgeon saves many of these cases, he only does so after a severe and prolonged operation on a patient in a bad condition to bear it, and with the prospect of failure always before his eyes: knowing all the time that months earlier he could have removed the same tumour without anxiety and with a practical certainty of success.

The danger of even a short delay is still more marked in those urgent crises which occur in this region. As an illustration take the case of the young man reported in England a little time ago. He had suffered from a mild attack of appendicitis and had recovered without operation. Later he was playing cricket at the oval and while bowling, with his arm swinging above his head and his right leg stretched out behind him, he fell to the ground with a sudden pain in the region of the appendix. He was removed to an adjoining hospital and was operated on within an hour or two. It was then found that the appendix had, in the former attack, ulcerated through, but had done so so slowly that the opening had become adherent to the front of the psoas muscle and so had not opened into the peritoneal cavity. While bowling the appendix had been pulled up, and the psoas muscle pulled down by the leg, with the result that the adhesion had been torn away and the perforation opened into the peritoneal cavity. As he was operated on at once he recovered without a bad symptom. If such an accident were to happen to an inhabitant of this country, he would almost certainly die. The operation would be delayed for some hours at least while his relatives talked the matter over; and in such a case a delay of only a few hours would mean the infection of the peritoneal cavity and the patient's death. I cannot do better than quote here from Moynihan's ideal book on abdominal surgery where a list of 376 cases of intestinal injury, collected by Siegal, is quoted. Of these, in many of whom the injuries were very extensive, about half died, *but*—

- of cases operated on within four hours of the injury only 15·2 per cent. died,
- of cases operated on within 5-8 hours 44·4 per cent. died.
- of cases operated on within the first 9-12 hours 63·6 per cent. died,
- of cases operated on later than 12 hours 70 per cent. died.

As in some way illustrating this advantage of early operation I have collected a series of Seventy-four cases of inguinal hernia operated on lately at the Sir Jamsetjee Jeejeebhoy Hospital here.

Thanks to the influence of the number of medical men in Bombay, the public here are slowly beginning to understand the benefits of early operation, and this has had an undoubted effect on the number that ended successfully. Of these 74 cases 49 were operated on for radical cure, and these include about a dozen strangulated and obstructed hernias which came so early that the protruded bowel was easily reduced under chloroform and a radical cure was done when the patient had been properly prepared.

These cases came early, at a favourable stage of the complaint, and the whole 49 recovered perfectly without any mishap. Our only difficulty in these cases was the prevention of superficial or stitch suppuration due to infection from the patient's own skin. The country method of bathing by pouring water over the person does not render him surgically clean. It is necessary to remove the superficial epidermis by soaking him in a hot bath, and a good system of baths with a plentiful hot water supply is a necessary adjunct to every Hospital. Among these cases were two of hernia "en bissac" in which the cæcum came down and being only partially covered by peritoneum lay in reality outside and behind the sac. In both these cases and also in another in which a large mass of omentum was adherent to the apex of the sac, the patients had been daily in the habit of reducing the hernia themselves, the reduction being "en masse," the sack as well as the bowel being pushed back into the abdomen.

Out of the 25 cases in which the hernia remained strangulated till reduced by operation nine died, and of these nine, with the exception of two in which the hernial contents had been damaged by violent taxis, the result was entirely due to delay in coming for operation.

Thus, those who came early for operation with an undamaged strangulated hernia were invariably saved; whereas of those who delayed long, some were saved with difficulty and some died. For example, one patient came after four days' strangulation with the bowel gangrenous in patches. This portion, with a foot above, was excised and an end-to-end anastomosis done, with the result that he passed a natural motion on the fifth day and recovered perfectly. Those who died had been suffering for from four to eight days, and one man gave the history of absolute obstruction to the bowel for twelve days.

I think we ought, therefore, both in season and out of season, to bring to the notice of the public that these mishaps after surgical operations could mostly be avoided if the patient came earlier for operation.

Moreove, we now have in spinal anæsthesia a most useful help to us in trying to save these serious cases. To put these cases in a position in which recovery is even possible a prolonged operation is necessary; to relieve the strangulation of the bowel is the least part of the operation.

The conditions to be overcome or removed are:—

1. The affected bowel is infiltrated with micro-organisms and its mesentery is in a condition of acute cellulitis from the same cause.

2. The mucous membrane, at least, of the bowel for some feet above the obstruction, is in a state of acute inflammation due to the poisonous contents which fill it to a greater extent than the rest of the intestine above.

3. This poisonous material which fills the intestine above, on relief of the inhibition to absorption by the strangulated gut, is rapidly absorbed and poisons the patient. It has therefore to be carefully and thoroughly emptied out before the operation is completed.

In one case of mine the mucous membrane of the bowel showed signs of gangrene for nearly two feet above the strangulation.

4. Portions of the scrotum are infected and have to be removed. In three cases the gangrene had spread to the scrotum and testicle from the hernial sac. Another case, in which this scrotal extension of infection only became evident after the operation, certainly died from the additional burden the inflammation of these parts threw upon his constitution. Modern methods of operating by increasing the rapidity of our work undoubtedly help us somewhat. Thus no time is lost in the old tedious dissection down through the scrotum. We now cut straight down on the external oblique aponeurosis in front of the inguinal canal which is then opened by slitting this aponeurosis up.

One incision through the cremasteric fascia then lays bare the neck of the sac and the band constricting it. A hernia director can then be pushed along the sac towards the scrotum and the coverings divided on it, to any required extent.

Again when the amount of bowel to be removed, and this, as I said before, usually includes a foot or two above the portion strangulated, has been decided on, a ligature tied through the apex of the mesentery, attached to this, prevents nearly all the troublesome hæmorrhage on dividing the mesentery. In fact, if properly applied, only one vessel bleeds at each side where the mesentery joins the bowel.

But this increase in speed is more than neutralized by the necessity of performing an anastomosis of the bowel in all cases that are not actually moribund. It is more and more becoming the accepted opinion now-a-days that this should be done. Two continuous sutures—the internal taking up all the coats of the bowel and the external a sero muscular one—only take in practised hands a few minutes more than does the tying in and fixing of Pauls tubes.

The use of these latter, both by the mental depression their use causes the patient, and by the sepsis which arises in the external and scrotal wound on their separation in 3 or 4 days, often throws too heavy a strain upon the patient's power of recovery. Such sepsis is usually unavoidable; for in these enfeebled patients the external wound as yet shows no signs of granulations or healing.

And if the patient does recover with their use, it leaves him with a serious and dangerous second operation to face.

Thus the necessary manipulations with the minute technique necessary to prevent infection, even in expert hands, takes much time, and this time is given us by the use of spinal anæsthesia. By its use, the part operated on is absolutely cut off from the patient's nervous system, and as the anæsthesia lasts for from one to two hours, it enables us to leave the patient with absolutely nothing to impede his recovery, if the days of uffering before the operation have left him enough strength to rally.

The patient feels no pain whatever during the operation, and often converses with his friends while it is going on; and in the few extreme cases I have as yet used it, the pulse has been as good and sometimes better after the operation than before.

All cases that have died after its use have been such that the smallest dose of a general anæsthetic would have killed them. If the spinal injection be not absolutely aseptic, trouble in the spinal cord might follow its use. But this is no objection; for it is on our ability to keep operation wounds aseptic, that the whole of modern surgery depends. As Cheyne and Binghard put it, in the dedication of their "Manual of Surgical Treatment," without the works of Lord Lister, most of the book could not have been written.

DISCUSSION.

Major H. Smith.—The heading of this paper is "Abdominal Surgery with special reference to Hernia." At least the first half of Major Bennett's paper is outside this subject. I am sure that there is no member of the profession who does not recognise the importance of early operation in serious diseases. Major Bennett comes after the preliminary half of his paper to the treatment of Strangulated Inguinal Hernia in a gangrenous condition, evidently with the object of advancing the cause of spinal anæsthesia, as, according to his view, you can safely spend hours over an operation on a patient suffering from this form of advanced obstruction of the small intestine under its influence; whereas as we all recognise these patients stand a general anæsthetic very badly if at all. As regards spinal anæsthesia, I have no experience but both Kocher and Cushing state that under its influence wounds run a markedly unfavourable course. In gangrenous hernia I would expect that the course of the wounds would be very unfavourable. Spinal anæsthesia throws the trophic and vaso-motor centres out of gear for several hours at the most critical time in such cases, whose general and local vitality is at its lowest ebb. As regards doing an intestinal anastomosis in the class of cases dealt with by Major Bennett, I am personally entirely opposed. It requires a dextcrous man to cut down, do an intestinal anastomosis and finish up in less than an hour. Spend an hour in an operation on such cases of advanced intestinal obstruction and I think you will have 99 per cent. of a death rate if not more. My own practice in such cases is to anæsthetise the skin with a streak of carbolic acid on the line of incision and to cut down without any other anæsthetic, relieve the constriction, open the gangrenous bowel freely and drain it. If the patient does not rally under this treatment, he will not rally under any treatment. If he recovers an intestinal anastomosis can be done a few weeks later under favourable circumstances.

Dr. A. Neve.—The question of immediate suture of the bowel after resection of gangrenous portions is raised. The condition of many of the patients is such that a prolonged operation is to be deprecated. No general anæsthetic is necessary, nor spinal anæsthesia desirable. At most a little cocaine, and under this anæsthetic the bowel may be opened and drained, and even may be flushed out with normal saline, which latter does good if left in the distal portion. The operation may then be completed at a subsequent date.

Major A. Street did not agree with Major Bennet's suggestion of reducing the hernia and stitching up the wound, nor with Major Smith in washing out the intestines. He remarked that the best is a simple incision, and soon the perist-

alsis sets in again as he had noticed that soon after such incision the fluid was ejected in larger and larger quantity. Professor Barker's cases with spinal analgesia never failed to heal, and this goes against the theory started by Major Smith.

Dr. R. B. Billimoria, B.A., enquired whether the symptoms in strangulation were so much due to toxic absorption (ptomaine poisoning) as to a B. Coli septicæmia, which are likely to pass through the damaged mucous membrane, and suggested the use of a vaccine of B. Coli communis if such were the case.

Major Stre·t.—The symptoms improve after drainage and so they must be due to ptomaine poisoning.

Dr. Wanless.—In urgent cases of intestinal obstruction and strangulated hernia, indicated by a rapid thready pulse with cold extremeties, subnormal temperature, dry tongue and scanty urine, we have to follow the aphorism of Murphey—"get in and get out quickly." The object is to let out the accumulated contents or relieve distension, which can be dcne with a general or spinal anæsthetic—both having drawbacks, morphia at most being used as a substitute and cocaine locally; and the operation may be completed at some future date. Death in these cases is due to toxæmia, which produces a toxic nephritis. In intestinal obstruction, too, the same rule: must be followed—rapidly open the abdomen, draw out the bowel and open it after a provisional purse-string suture, the loop of bowel being kept in the wound by a couple of sutures. But in cases not showing this extreme toxæmia, with a good pulse and moist tongue, and obstruction on distal side of the cœcum one can proceed to do a resection if necessary. This was the procedure recently adopted at Miraj, the cause of obstruction being a mass of round worms. I want to make a plea for the use of ether anæsthetic in this latter class of cases and in abdominal surgery generally. In 1908 there were performed in the Miraj Mission Hospital 136 abdominal operations, with a mortality of 5·30 per cent. I attribute this low mortality for India largely to the use of ether. We store the ether, in good stoppered bottles, beneath the ground. Instead of silk I would prefer catgut in adominal surgery, and I have found celluloid thread also useful and good.

Reply:—I do agree that in a moribund condition the best is to let out the contents and do nothing more. My contention is: can we increase the cases of doing complete operation. The bowel is paralysed, absorption increases, paralysis goes on increasing: and I believe we must try to remove every point which might be going against the patient, though it takes time, and I would therefore like to operate on these under the influence of a spinal analgesia.

EPIPLOPEXY.

BY CAPT. T. S. NOVIS, I.M.S.

In bringing to your notice the operation of Epiplopexy for Ascites, my exeuse is, that in India, to the best of my knowledge, this method of treatment has not had the extended trial which it merits. Aceording to Osler the causes of ascites are :—

1. Loeal Causes.—
   (*a*) Chronie Inflammation of the Peritoneum.
   (*b*) Portal Obstruetion.
   (*c*) Tumours in the Abdomen.
2. General Causes as a part of general dropsy due to—
   (*a*) Heart Disease,
   (*b*) Chronie Ephysema.
   (*c*) Cirrhosis of the lung.
   (*d*) Bright's Disease.
   (*e*) Hydræmic states of the blood.

In eertain cases of heart disease, dropsy may be confined to the peritoneum.

It is in aseites due to local causes that operative treatment is likely to benefit the patient; chronie tuberculous peritonitis of the ascitie type has been treated with suecess for years, by opening the peritoneum and letting out the fluid. The treatment of ascites due to cirrhosis of the liver also, of late years, has been passing gradually into the hands of the Surgeon. Purges and other medieines, in the first plaee, were supplemented by repeated tapping or continuous drainage with Southey's tubes. The next step was ineision, with or without washing out the peritoneum, and at present Epiplopexy (suture of the great omentum to the anterior abdominal wall) to establish eollateral eirculation is gradually coming into favour.

Patients suffering from eirrhosis of the liver are frequently met with in India, many of whom have not been addicted to alcohol. Riekets, Syphilis and Infectious fevers, sueh as Typhoid, aceount for a eertain number of these eases; it is however diffieult to get a satisfaetory history from the hospital elass, but, in all probability, the greater number of non-alcoholic cases is due to malaria and highly seasoned food.

The aetual eause of aseites was generally believed to be baek pressure due to obstruetion of the branehes of the portal vein in the liver, but that this is the only eause is very doubtful, as there does not appear to be any relationship between hæmorrhage from the tributaries of the portal vein, undoubtedly caused by baek pressure, and ascites; some eases suffering from frequently repeated hæmatemesis and melæna remain free from ascites while others with well marked aseites do not suffer from hæmorrhage until the late stages of the disease.

Ketehen and Thompson (*Practitioner*, December 1907) give the following reasons for their belief that ascites is not due to baek pressure —

(1) Ligature of the portal vein by Starling produeed no aseites.

(2) Thrombosis of the portal vein does not immediately produce ascites.

(3) Atrophic eirrhosis often produees considerable pressure on the portal vein before effusion takes plaee, and, as Allehin pointed out, should lead to effusion into the stomaeh and intestines and not into the peritoneum, as it is on the mueous surface rather than on the peritoneal surfaee that engorgement of the eapillaries takes plaee. They attribute the aecumulation of fluid to an inflammatory proeess affecting the peritoneum; elinieally

they divide all cases into two groups with intermediate cases :—

Group I.—In which peritonitis is a local condition produced by the same poison as the cirrhosis, but the liver is still sufficiently healthy to carry on its functions for years ; these cases improve after tapping and are likely to be relieved by operation.

Group II.—In which the peritonitis is toxic in origin ; the liver cells have been destroyed to such an extent that they cannot exercise their function, and products which should have been eliminated, find their way into the general circulation and poison the body generally, including the peritoneum ; these cases do not improve after tapping and are unsuitable for operation.

The view that peritonitis of a mild type is the cause of ascites is supported by the fact that sometimes adhesions are found between the omentum and abdominal wall, or elsewhere in the peritoneal cavity in patients who have undergone no previous operation or tapping.

Whether the cause be back pressure, peritonitis, or loss of balance between secretion and absorption in the peritoneum, there can be no doubt that in favourable cases, the formation of an anastomosis between the veins of the omentum and those of the anterior abdominal wall provides a channel for absorption of excess of peritoneal fluid, thereby relieving the patient of a distressing symptom, and leading, in many cases, to improvement of his general health, and possibly checking the progress of fibrosis in the liver by relieving the congestion of the portal system. Nature generally attempts to establish a collateral circulation by dilating the existing communications between the portal and systemic veins, as shown by the occasional presence of a varicose ring at the umbilicus where the veins in the falciform ligament join those of the abdominal wall, and the unusually vascular condition of the abdominal wall found in most cases of ascites at the time of operation.

How extensive the anastomosis may become after operation is illustrated by a case shown by M. Gendre and M. Deglos at the Societe Medicale des Hopitaux of Paris (*Lancet*, January 19th 1907). Epiplopexy had been performed in their patient in 1903, and three years later the patient who was suffering from severe jaundice and enlargement of the liver and spleen was operated on by M. Hartmann. The muscles of the abdominal wall near the scar were so vascular, that the condition was almost one of angioma ; the operation had to be stopped on account of bleeding, but the patient rapidly improved, probably owing to the blood letting relieving the pressure in the biliary canaliculi. Sometimes dilated veins are seen on the anterior abdominal wall, as in a successful case reported by Monro and MacGregor (*Lancet*, May 5th 1906) in which, eight months after operation, a distinct vein was seen running from the scar to the left groin. In two of my own cases, seen twenty-three and eighteen months respectively after operation, the veins of the abdominal wall were somewhat more prominent than usual.

Unfortunately I have been unable to consult Talma's original paper, but, since its publication, the operation has been performed with numerous modifications. Some surgeons employed drainage after the operation, the drainage tube being introduced as a rule through an incision above the pubes, (*Practitioner*, December 1907 and *Lancet*, February 15th 1908) ; others have closed the abdomen at once (*Lancet*, May 5th 1906). The great omentum has been sutured to the anterior abdominal wall without roughening the surfaces (*Lancet*, May 5th 1906 and February 15th 1908). The parietal peritoneum has been reflected on either side of the wound, and the omentum stitched to the raw surface thus produced (*Practitioner*, December 1907). The superior surface of the liver and the corresponding surface of the diaphragm, after freshening, have been joined with sutures (*Practitioner*, December 1907). In many cases it has been found necessary to tap the peritoneum two or three times after operation, to draw off reaccumulated fluid.

In my first six cases the operation performed was as follows :—

An incision $3\frac{1}{2}''$ to $4''$ in length was made in the middle line, midway between the ensiform cartilage and the umbilicus, after the fluid had been allowed to run away, the parietal peritoneum was scarified on either side of the wound, over an area about $1\frac{1}{2}''$ wide extending laterally as far as it was possible to reach conveniently, the omentum was brought up and joined with continuous silk suture (medium size) to the scarified area, the abdomen was then closed in layers, the omentum being included in the first row of sutures. In two cases through and through suture was employed to close the abdomen, as it was desirable to finish the operation as speedily as possible. In no case was drainage employed, and though some fluid invariably reaccumulated, it was never found necessary to tap the peritoneum after operation, as in all cases the fluid disappeared entirely after a time.

Case I.—Male, about 40 years of age. This patient was under treatment in the medical wards of the J. J. Hospital about 3 years ago. He had been tapped several times, and although some improvement followed, the fluid quickly reaccumulated, and the abdomen again became distended within 10 days after each tapping. At Lieut.-Colonel Meyer's request Epiplopexy was performed, the patient making a good recovery ; although some fluid reaccumulated, it became absorbed without any further treatment, and the patient left hospital, greatly improved in health, 3 months after the operation. He promised to return if he had any further trouble, but I have not had the opportunity of again examining him.

Case II.—Thakya Sooka, male, aged 30 years, admitted into Nasik Civil Hospital for ascites on January 4th, 1907. His abdomen was distended with fluid, causing considerable divarication of the recti muscles and a fair sized umbilical hernia. The liver was pushed up to the 4th intercostal space.

The heart sounds were weak, but no valvular disease could be detected.

The urine was normal in every respect. There was no general œdema, or puffiness about the eyes, no history of alcoholic or other excesses. He was quite unable to work, but could walk with difficulty, and, though he had improved after tapping, which had been performed several times, the peritoneum quickly refilled.

The operation was performed on the 26th January 1907; he made a rapid recovery and was discharged from hospital, February 27th, 1907. For the first few days after operation he suffered from gnawing pain in the abdomen, and had a little fever (99°F. to 100°F.) at night, but though the pain disappeared on the fourth day, he was troubled with flatulence and borborygmi and at times, had slight recurrences of the gnawing abdominal pain during his convalescence. Some fluid reaccumulated, but at the time of his discharge, it had been absorbed almost completely. He was seen again in May 1907 when he appeared in good health, and had put on flesh. He had walked in from his village, eight miles away, and was going to walk back the same day. He said he felt quite well and was able to do his work, but still suffered from flatulence and borborygmi, the noises in his stomach being so loud that, at times, he was frightened.

This patient was last seen on December 2nd, 1908, when he appeared to be in excellent health. His abdominal wall had regained its tone, the divarication of the recti muscles and the umbilical hernia having completely disappeared. He was quite cured.

Case III.—Ittoo Hanmanta, male, admitted into hospital for ascites on February 23rd, 1907. His organs were fairly healthy, but his general condition was poor, urine normal.

He was tapped a month before admission, and had been tapped on several previous occasions. The operation was performed on March 6th, 1907, and though the patient did well for two days, he developed pneumonia on the 3rd day, and died on March 14th, 1907, eight days after operation. The abdominal wound had healed by first intention.

Case IV.—Poonja Kedoo, male, aged 45. This patient said he had had colicky pain four months before admission, followed by enlargement of the abdomen. His bowels were always constipated. No history of alcohol. When first examined his abdomen was full of fluid, the size of his liver could not be definitely made out. Heart sounds were weak, but there was no valvular disease, urine was scanty but contained no albumin or sugar, tongue was furred and appetite bad. No œdema of feet or face. Operation was performed as usual; the liver was found to be small, cirrhotic and very bossy; the patient rallied after the operation, and appeared to be doing well until the following morning, when he complained of tightness of his bandage and gnawing pain in the abdomen, the bandage was loosened, the pain however continued, and at 4 p.m. he suddenly collapsed, and died at 5 p.m. His abdomen was very much distended and pulse quick. *Post-mortem* examination: some serum in the peritoneum, no hæmorrhage; liver very small, extremely cirrhotic and bile stained.

Death was in all probability due to insufficiency of liver tissue; the extra strain thrown on the system by the operation no doubt hastened the end.

Case V.—Vithal Shoma, admitted into hospital for ascites on April 15th, 1907. He had come up from Malegaon for operation. Formerly he had been a heavy drinker, but had given up alcohol for 4 years. He had a chronic cough, and suffered from attacks of asthma.

On admission he was suffering from ascites with some swelling of the feet and face. His heart sounds were feeble, but no valvular disease could be detected; his lungs showed signs of chronic bronchitis. Spleen normal; liver could not be definitely made out, but appeared small; urine scanty, sp. gr. 1020, no sugar or albumin.

Though not a favourable case, it appeared to me that cirrhosis of the liver was the primary disease, and that the fluid in abdomen was pushing up the heart and embarrassing its action, epiplopexy was therefore performed.

The patient stood the operation well, and the wound healed after a stitch had been removed. The swelling of the feet remained, but the patient passed urine more freely than before. The urine was of a reddish colour like cochineal, probably due to the presence of one of the hæmoglobin compounds as no blood corpuscles were present. The patient was discharged on May 10th, 1907, his general condition was much the same as it was before operation, except that his peritoneum was almost free from fluid, and his urine had increased in quantity and was red in colour.

The Medical Officer at Malegaon kindly wrote to tell me that the patient returned to his home and died three or four weeks later, and that there was no reaccumulation of fluid in his peritoneum up to the time of his death.

Case VI.—Amruta Khandoo, male, aged 40, admitted into hospital on June 9th, 1907, suffering from ascites.

Heart and kidneys healthy. No previous tapping. Operation on July 3rd, 1907. The liver was found to be cirrhotic, some adhesions had formed between the great omentum and the anterior abdominal wall, and between the liver and diaphragm. The wound healed by 1st intention, and the patient left hospital on July 20th, 1907, on which date a little fluid had reaccumulated in the abdomen, but his general health was improved.

The patient returned to hospital for rheumatic pains in his joints, and I had the opportunity of examining him on December 2nd, 1908, when his condition was as follows:—

Abdominal wall firm except for a slight ventral hernia at site of operation, no fluid in abdomen, no distension, area of liver dulness somewhat smaller than normal, spleen 2″ below the costal margin. He stated that his health had been fairly good since the operation, and that he had not been troubled by any reaccumulation of fluid.

Of these six cases, three were cured of ascites and greatly improved in general health, one died suddenly 30 hours after operation, one died from pneumonia, and one recovered from the operation, and returned home with

the wound healed and without much fluid in the abdomen, but his general health was not improved and he died a few weeks later.

Now these cases show an immediate mortality of 33 per cent., but considering the condition of the patients at the time of operation it may be looked upon rather as a saving of life in 50 per cent.; moreover, Cases IV and V were not suitable for operation, and a mistake was made in attempting to relieve them by surgical interference, as death in Case IV was hastened thereby, and Case V was in no way benefitted. Œdema of the feet and albumen in the urine, even if they decrease after tapping, render the prognosis less favourable, though in the latter case operation may be justifiable, the condition of the heart and kidneys should be carefully investigated before deciding on active interference. The effect of tapping on the patient will generally form a fairly reliable indication as to his ability to stand operation. As these patients are all bad subjects for operation, and even with very careful selection the mortality will always be high, any modification that will reduce its severity and enable the operator to dispense with general anæsthesia should be welcome, provided its ultimate results are good. Narath's modification of Talma's operation promises to reduce the mortality, as this procedure is simple and can be performed quickly under cocaine anæsthesia ; Corson of Savannah, who has published a successful case, strongly advocates its general adoption (Annals of Surgery, December 1907) ; the technique is as follows : —

A small incision is made in the middle line below the ensiform cartilage, and after letting the fluid out of the peritoneal cavity, a bunch of omentum is brought up and fixed with catgut sutures between the skin and the muscular wall of the abdomen. This may be done on one or both sides of the incision, the abdomen is then closed in layers; it is a simple procedure, quickly performed, and does not cause much shock. The actual operative mortality therefore should be very small. The objection to the operation is the presence of an omental hernia after operation, and the possibility of intestine finding its way out of the abdomen along the omentum ; this objection however is theoretical rather than practical, as the hernia is situated well above the umbilicus where it is not subject to much strain.

My experience of this procedure is limited to two cases in which the operation was performed a few weeks ago in Nasik by Major Hudson, I.M.S., and myself. In each case the patient suffered from very little shock and the wound healed by first intention, one patient left hospital greatly benefitted, the other unfortunately was attacked by dysentery and left hospital, against advice, in a critical condition ; sufficient time has not yet elapsed to enable us to judge whether the ultimate results obtained will be satisfactory.

In conclusion, I wish to advocate a full trial of this operation for ascites, in carefully selected cases, on whom the effect of tapping has been tried. The operation should be as simple as possible, no drainage should be employed as it appears to be unnecessary, and the presence of a drainage tube in the abdomen is dangerous, in that it is an open channel for the entrance of germs ; this is especially so in India, as the skin of patients on whom we generally operate is extremely difficult to render aseptic.

Drawing off the fluid which reaccumulates after operation is, as a rule, uncalled for, as if the patient progresses favourably it will gradually become absorbed.

DISCUSSION.

Major T. Jackson.—During the past year I have performed Epiplopexy three times for ascites due to cirrhosis of the liver.

Case No. I was a female, aged 30 years, a Mahomedan by caste. She had been repeatedly tapped without benefit during the five months preceding the operation. Her urine was free from albumen. After the operation she recovered rapidly and went out of the Hospital in good health. I have not heard of her since.

Case No. II was a male, aged 30 years, a Dhed by caste. Suffered from ascites due to liver cirrhosis, was tapped twice without benefit. No albumen in urine. Operation relieved him as far as the ascites was concerned, but the patient did not regain strength rapidly and went out of Hospital 18 days after operation and I have not heard of him since.

Case No. III was a male, aged 50, a Lohar by caste. He had been suffering from ascites due to cirrhosis of liver. Illness of about 8 months' duration. Emaciation was extreme. The abdomen was very much distended and the feet, legs and scrotum were œdematous. Urine free from albumen.

After operation the œdema of feet and scrotum disappeared quickly. The patient died of exhaustion due to Hæmatemesis about 36 hours after operation. Had Hæmatemesis not set in, I had hopes of a good recovery in this case as the œdema of the feet and legs had rapidly disappeared and the patient's condition was very satisfactory on the morning following the operation.

I consider the operation a very valuable one in selected cases of ascites.

I performed the operation by making an incision to the outerside of the rectus muscle between the ensiform cartilage and the umbilicus 5-6 inches in length separating the peritoneum from the abdominal wall in both sides and suturing a portion of the great omentum into the space thus formed and closing the abdominal wound in layers, leaving a gauze drain in the upper part for two or three days.

In future operations I intend not to attach so much omentum to the abdominal wall. The rapidity with which the œdema disappeared in my third case led me to think that a small portion of attached omentum would be sufficient.

Dr. Wanless.—My experience amounts to about 14 cases. Of the 8 done in 1908, 5 were done under cocaine, and 3 under ether. The cocaine cases in general were not so satisfactory as much manipulation was not possible as under general anæsthesia. All cocaine cases required retapping, and one of the ether cases required it too ; the remaining 4 ether cases were much benefitted, the urine doubling, or trebling in quantity. The average stay in the hospital was 45 days. The operation we now perform consists of a 3 to 5 inch incision in the median line above the umbilicus, the fluid is syphoned off, and the surface of the liver and diaphragm scrubbed with gauze. A pocket is then made on each side of the incision between the peritoneum and overlying structures, the omentum is drawn into this pocket by means of a mattress stitch of catgut entering at and ending on the skin about two inches from the abdominal wound where it is tied. A similar pocket is made at the lower extremity of the wound and the omentum similarly fastened. The peritoneum is closed over the base of the protruding omentum for a couple of inches and the skin sutured over all by the use of silkworm gut. I doubt if scrubbing of the liver and diaphragm does much good in atrophic cases, since the fluid reaccumulating causes these surfaces to float apart. In some cases the omentum is greatly atrophied and shrunken so that it is with difficulty attached to

the abdomen. I have known of only one case of permanent relief, but I believe we can expect marked relief in 50 per cent. of cases, and better still if we learn to select our cases.

Major A. Street.—I believe Capt. Novis's successes were due to formation of large artificial lymphatics by passing sutures backwards and forwards; and may be that Dr. Wanless's failures were due to the use of catgut, which gets absorbed, instead of silk.

Colonel Roberts.—I would not advise this operation, especially if the patient's condition is low. In fact, in one case I had found adhesions formed by nature without any such operation, but without any benefit.

Reply.—Dr. Wanless subsequently tapped his patients, but left them untreated, and in three successful cases, the fluid got reabsorbed. Those cases which seem to improve after tapping must be given a trial by this operation.

ONE CAUSE OF CANCER AS ILLUSTRATED BY EPITHELIOMA IN KASHMIR.

By ERNEST F. NEVE, M.D., F.R.C.S.E.,

Surgeon to the Kashmir Mission Hospital.

During the twenty-five years ending with 1906, the total number of tumours removed by operation in the Kashmir Mission Hospital was 4,902. Of these, 3,182 were simple tumours and the remaining 1,720 were malignant. That the proportion of malignant disease should be so unusually high as to form almost one-third of the total number of tumours is due to the frequency of Epitheliomata. Of the 1,729 malignant growths, no less than 1,189 were epitheliomatous.

DISTRIBUTION.

The distribution of these is interesting. While not a square foot of the whole body surface can claim immunity, the commonest sites by far were the thighs, and the abdomen, which between them account for as many as 848 epitheliomata. Next in frequency comes the breast with 48 (not including Scirrhous Carcinoma). The other most frequent sites were leg 46, chest 21, face 19, hand 16, foot 10, rectum 6, lip 5, ear 5, and tongue 4.

In comparison with Great Britain the infrequency of epithelioma of the tongue and lip will be noticed. This is partly due to the use of the hooka, instead of the pipe, obviating as it does irritation by heat.

In Kashmir the sites of election for epithelioma are the thighs and abdomen and to a lesser extent the breast, the chest and the legs, all of which are exposed to a special source of irritation, the kangri or portable fire basket. This is an earthenware pot with a capacity of about half a cubic foot; it is surrounded by basket work and surmounted by a wickerwork handle and is carried by the Kashmiris under their clothes during the five colder months of the year (Fig. 1). The ordinary Kashmiri wears a garment called a 'pheran,' which is rather like a smock frock. Under this many wear loose cotton drawers, but the poorer people have only a lungooti, which may be compared to scanty bathing drawers. In walking, the kangri is held in contact with the abdomen; but when the Kashmiri sits on the ground he usually places the kangri between his thighs. This explains why the majority of the epitheliomata should be on the thighs, why the abdomen should be so frequently affected and also why the breasts, the chest and the legs all of which are exposed to the heat, should sometimes suffer? Exposure to heat is the determining factor in the distribution of these epitheliomata and accounts for their frequent occurrence. Of the total 1,189, it is probable that 963 were really due to the kangri and may be designated Kangri burn Epitheliomata.

The favourite site of the growth is about the middle of the inner aspect of the thigh and on the abdomen, midway between the umbilicus and pubis. They are sometimes multiple. Epitheliomata on the abdomen are usually in the middle line or close to it. On the legs, they are found on the inner sides of the calves. The front of the chest and the most dependent part of the breasts are liable to attack.

Kangri burn cancer appears to be commoner in men than in women. In our records the proportion is as two to one. As only one-third of our total in-patients are women it is possible that many may have gone without treatment or sought it elsewhere. Owing, however, to their occupations in cooking and attending to young children the women do not, perhaps, use the kangri quite so continuously as the men.

The average age of patients with epithelioma is 55. There were very few cases under 40 years of age. About 7 per cent. were over 70.

PRE-EPITHELIOMATOUS CONDITIONS.

The great frequency of old scars is significant. These are tangible evidence of previous injury. Most of them have arisen from the burn of the kangri in early life. Spots or patches of pigmented skin are common. These are distinct from the scars and are often to be observed on the abdomen, thighs and legs. They consist of dry, slightly scaly, dark brown or black macules or papules, composed obviously of pigmented epithelial overgrowth. They vary in diameter from about a millimeter to one or two centimeters and may project from the surface a fraction of a millimeter. Another condition showing increase of pigmentation is the mottling which is so often present. Owing to the heat, the superficial veins of the thighs and abdomen become dilated and a deposit of brownish pigment marks their distribution.

Fig. 6.
Excavated secondary epithelioma of groin with thin discharge from lower angle. The upper edge of the primary growth can be seen below.

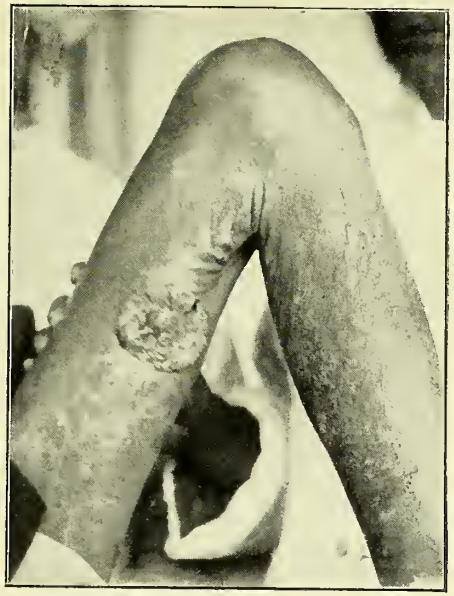


Fig. 3.
Kangri burn epithelioma. Raised type: Observe the scar tissue above and below, the mottling of the thigh and a dilated vein and the scaly and pigmented condition of the calf.

Fig. 5.
Secondary epithelioma of groin. Note the mottling of epigastric region, the effect of exposure to continued heat.

Fig. 1.
Kangri (reduced to $\frac{1}{20}$th).

Fig. 4.
Small epithelioma thigh in the midst of scar tissue. The groin is infected.

Fig. 2.
Kangri burn epithelioma. Mixed type with raised margins and craterlike centre (reduced to $\frac{1}{3}$rd).

This is also found to a less extent on the chest and legs. In some cases horny growths occur, with a diameter at the base of two to four or five centimeters and projecting from the surface to a similar extent. Dr. Arthur Neve has described an interesting case of this kind in which, at one part, the transition into epithelioma was demonstrable. Between the little pigmented papules and the large horny tumours there are various warty and scaly conditions due to surface irritation and all of them quite common. On the inner side of the thighs there is often a more acute condition, resembling chronic eczema and associated with redness and a tendency to desquamation. This gradually shades off into the formation of actual scar tissue, which again, under the influence of repeated irritation, becomes slightly raised. The following is an illustrative case. A, æt. 55, male. Duration one year. Scars of kangri burns on inner aspects of middle thirds of both thighs. On the left side itching started a year ago and was so annoying that besides scratching it the patient applied leeches. Soon afterwards the first thickening appeared and it has spread slowly since. There are now small irregular raised patches with a total area of two square inches, on the inner aspect of the middle of the left thigh. The edges are not steep but gradually lose themselves in the scar from the kangri burn. There is no pain and no ulceration. These wheal-like patches are freely movable over the fascia. The glands of the groin are distinctly palpable but are not enlarged.

CLINICAL PATHOLOGY.

There are two main types of kangri burn epithelioma, the raised and the excavated. But both conditions are often associated in the same case. (Fig. 2.) The raised type may consist of a flat, thickened non-ulcerated area. More commonly the surface is eroded. Ulceration is usually soon followed by fungation and in the majority of cases of the raised type there is mulberry-like projection or even cauliflower excrescence. (Fig. 3). Such a tumour may project one and-a-half to two inches from the surface and its base may measure as much as three or four inches across. In extreme cases the tumour when removed may weigh as much as two or three pounds. The average size is smaller. Two inches in diameter is a common measurement. The excavated type (Fig. 6) may consist of small or large ulcerated patches with steep or undermined edges. The excavation is often deep and with irregular recesses. In the mixed form, the growth as a whole is raised and circular or oval and in the centre is a deep crater-like depression. Sometimes the appearance is like that of a sea-anemone, with a central depression and villi radiating to it from the circumference. In other cases a portion of the growth may be fungating and another part may show deep excavation. All these growths are very septic. They are often covered with scabs and the skin around is sodden with fetid discharge, which dries and becomes adherent in dense masses around the edges of the tumour. On the abdomen the excavation is apt to be more marked than in the thigh. Muscles, peritoneum and even the surface of ribs may be attacked.

Glands are slow to show signs of infection except where there is marked excavation. In the case of the thigh they are found in six situations which are usually infected in the following order: along the upper part of the Internal Saphenous vein, deep in Scarpa's triangle, close to the spine of the pubis, transversely below Poupart's ligament, and in advanced cases the deep femoral and even the external iliac glands are involved. In abdominal epitheliomata, if they are below the umbilicus, the inguinal glands are affected first and later on the external iliac; if the growth is above the umbilicus, the anterior axillary glands are first infected. In later cases the deep glands along the front and inner aspect of the axillary vessels may be attacked. I do not remember to have seen any case in which the posterior (subscapular) glands were affected; but I remember one in which there was a chain of three or four small glands across the side of the chest from the epigastrium to the axilla. Infected glands soften early. I have removed glands as large as a bantam's egg, and they frequently attain the size of a pigeon's egg. I have never met with any case of visceral infection. When the glands break down they cause diffuse infiltration. The skin overlying them becomes red and brawny, suppuration occurs, and sooner or later the skin gives way and the secondary growth in the groin or axilla presents all the characters of the primary ulcer except that it is deeper and much more widely diffused (Fig. 6). From its ragged cavities and deep recesses there is copious foul discharge, and after weeks or months of suffering the patient dies of exhaustion, septic intoxication or hæmorrhage. The external iliac, femoral or axillary arteries may be opened into by ulceration comparatively early in a case of this kind.

The appearances of the kangri-burn epithelioma on section are characteristic. The edges are thickened and heaped up and show a tendency to invade contiguous tissues. The floor is thinner than the edges, but, like them, is light grey or cream coloured, of fibrous appearance and showing translucent and opaque patches. The mass of the tumour, mottled red and grey, is made up of embryonic tissue, with numerous blood vessels and a scaffolding or framework of fibrous tissue. On the free surface there are frequently villi and papillary granulations. The tumour is of unequal consistency, some parts being friable and others very tough. Rarely there are woolly-looking patches composed of cholesterine crystals. Stiles' method is useful in demonstrating microscopically the epithelial distribution. Microscopically the growths are found to be typical squamous celled epitheliomata, with abundant cell nests. Cells obtained by scraping are large, often polynucleated and of various shapes. The lymph glands on section show in the early stages grey spots or patches and later on soft granular pultaceous areas, which are found to consist of large epithelial cells of the same type as those of the primary tumour.

RESULTS OF TREATMENT.

The only treatment of avail is excision. For small growths no doubt X-rays might be suitable, but patients prefer quick remedies. By prompt and wide removal a radical cure can be attained in the majority of cases. In small tumours, early treated, simple excision is sufficient. In tumours of longer history, whether small or large, it is usually advisable to remove the lymph glands if there is the least doubt as to their enlargement. In the case of the groin and Scarpa's triangle the glands are well under observation, but the pubic group require careful examination. In tumours of the epigastric region both axillæ must be most carefully investigated, and absolutely cleared out, if there are any enlarged glands.

At the time of operation lymph glands should be dealt with before the primary tumour as the latter is invariably septic. It is most important to avoid rough handling, lest infected glands should be torn, burst or cut through and thus the wound become infected. The primary growth needs still greater care as it is also septic. It may be previously treated with Chloride of Zinc or the actual cautery. It is best not to handle it at all.

The line of incision should be carried round and deepened at one point where with the volsellum the healthy edge should be seized external to the ulcerated area and the tumour raised and dissected out. In the abdomen it may be necessary to remove portions of the rectus muscle. If the growth is in the middle line it may have penetrated the linea alba and involved the peritoneum. Small areas of peritoneum may be removed, but extensive implication negatives operation, as the edges of the wound cannot be brought together and omentum or bowel remains exposed. In one of my cases in which this happened the patient succumbed in the second week from a mild peritonitis with septic absorption. Occasionally very extensive operations are required as in the case of K. S., male, age 30, who came with an epithelioma in the epigastric region of one year's duration. A line of thickened lymphatics could be felt connecting the tumour with the axillary lymph glands. Here an incision a foot and a half long was required and the whole intervening area together with the axilla was cleared out. In advanced cases, even if the primary tumour can be removed the glandular condition often precludes operation, owing to the undefined induration (Fig. 5). In such cases excision is impossible, or if apparently achieved, it is sure to be followed by recurrence in the depths of the wound, excavation, or fungation and sepsis. The risks too of early hæmorrhage from ulceration are increased. These are the cases which are mainly responsible for mortality after operation. Of the total 1,189 cases, 6 died as the result of, or their deaths were hastened by, operation—a mortality of just under $\frac{1}{2}$ per cent. Of these four were due to prolonged suppuration in recurrent growths, one died of peritonitis, and one from hæmorrhage due to ulceration into the femoral artery. But this is very far from representing the mortality of the disease. There are also the cases which, when first seen by us, were too far advanced for operation and the cases of recurrence after operation.

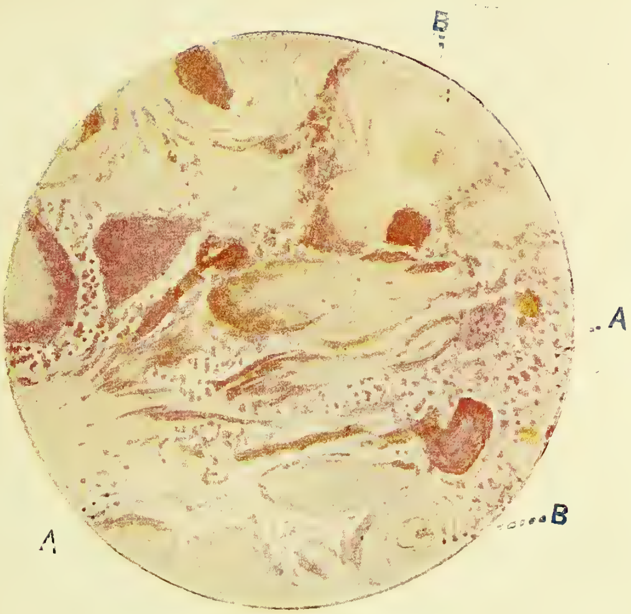
Recurrence may take place at the site of the primary tumour or in the glands; in the former situation it may be due to the operation having failed to remove all the disease. But as many of the patients disregarding all warnings still continue to use the kangri, there is no reason why the healthy scar of a successful operation should not become epitheliomatons from the irritation of continued heat and there is also the possibility of epitheliomatous changes taking place in other old cicatrices in the neighbourhood. On the other hand recurrence in lymph glands is usually due to an incomplete operation; but not always, because a recurrent local growth may infect fresh glands. Sometimes there is quite a long history, of twenty years or more, and yet there is no glandular enlargement. About 10 per cent. of the cases have a history of one to five years' duration. The average duration is about fifteen months. Forty-three per cent. of the cases however showed more or less marked traces of glandular infection. There is sometimes uncertainty. As a general rule a small growth, if superficial, is slightly malignant, is slow to grow and still slower in infecting glands. But there are striking exceptions (Fig. 4). I have seen an epithelioma no larger than an almond which has produced glandular enlargement. And sometimes a tumour of very old standing and slow development will suddenly begin to grow rapidly and assume very malignant characters. Some too are deeper than they look.

In 300 cases the records of which I have examined I find that in twenty the disease had recurred after a previous operation, but the cases were considered suitable for another operation. But every year we see cases of recurrence which are no longer fit for operation. In the year 1907 the total number of epitheliomata operated upon was 62. In addition to this there were 6 cases which were too advanced for operation. Some of these were probably not recurrent cases but tumours which at the patients' first appearance were already too advanced for treatment. On the other hand there must be a good many cases of recurrence which do not return to us. So I fear that recurrence may altogether be as frequent as 20 per cent.

Compared with mammary cancer, the disease is superficial at first and so the diagnosis is early. Superficial lymphatics are first affected which gives surgery a much better chance, and in the case of the thigh the glands of the groin are under observation and enlargement is unlikely to escape detection. Consequently the disease is not nearly so malignant as scirrhous carcinoma.

The causes of cancer in general are still involved in obscurity. The disease has been attributed to heredity, special articles of diet, the use of salt, nerve strain, parasitic infection and a variety of other conditions. It has long been realized that mechanical and chemical

One Cause of Cancer as illustrated by Epithelioma in Kashmir.



× 100 picrocarmine.

Fungating Epithelioma with Cauliflower Excrescence.

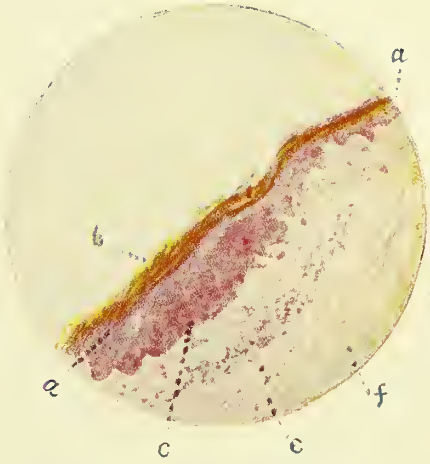
A.—Corium with active proliferation and stroma extending between masses of cells.

B.—Epithelial cell masses arranged concentrically, laminated and keratinous.

Epithelioma in Very Early Stage.

(*Section from scaly spot close to epithelioma.*)

a.—Normal epidermis.
b.—Thickened cuticle.
c.—Obliteration of papillæ by epithelial overgrowth.
d.—Stratum granulosum well stained.
e.—Proliferating cells of Corium.
f.—Elastic fibres of connective tissue.



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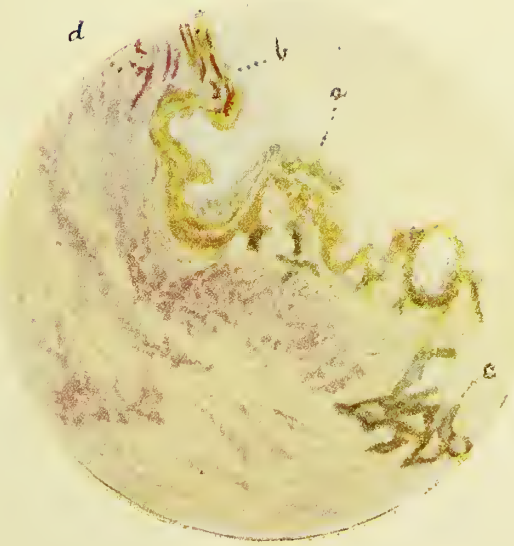

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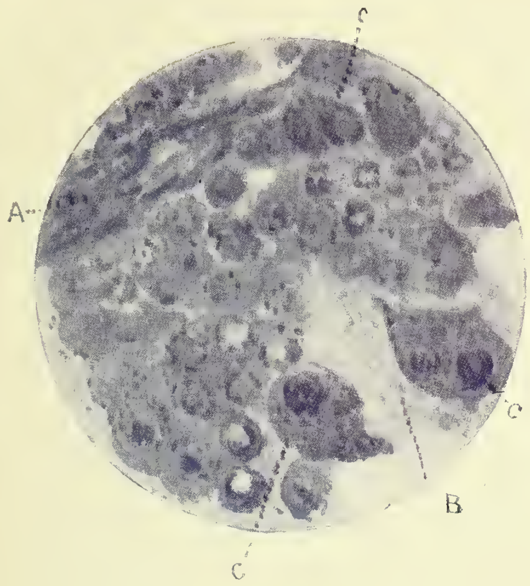
Surface of Excavated Epithelioma.

a.—Cell debris from surface of wound.

b.—Stratified cells like those of stratum corneum.

c.—Pigmented fragments of epidermis with papillæ of corium cut obliquely.

d.—Corium with actively proliferating cells resting on co-elastic tissue.



× 100 Hæmatoxylin.

Lymph Gland Infiltrated by Epithelioma.

A.—Fibrous tissue underlying capsule.

B.—Primary trabeculæ.

C.—Masses of nucleated epithelial cells occupying and distending the lymph sinuses. They are arranged concentrically, the more central cells being laminated and horny.

Section from Advancing Edge of Epithelioma.

Section and Report by Cecil Rowntree, Esq., F.R.C.S., Cancer Research Department, Middlesex Hospital.

a.—Thickened cuticle.

b.—Highly stained nuclei of stratum granulosum.

c.—Papillæ irregular and longer than normal,

d.—Dense clouds of cells, mostly plasma cells, in the superficial layers of the corium.

Hair follicles, sebaceous and coil glands have disappeared.

× 100 Hæmatoxylin.

irritation is dangerous, especially in elderly people, as for instance, in the case of a sharp tooth irritating the tongue, buccal cancer from betel chewing and the application of caustics to warts. In the kangri burn cancer we have a most important illustration of the effect of irritation by heat. Year by year we have, going on under observation, the experimental production of cancer by the action of one particular cause on elderly subjects. And we have every stage, from the earliest signs of epithelial proliferation to the most advanced cancerous growths with secondry deposits. The evidence of the Kashmir kangri burn cancer appears to me to be against a parasitic theory of the origin of cancer. It is a local disease arising from a local cause. It arises on a site which is in a measure protected by being covered. The hands, face and feet which are more exposed are much less affected. The patients affected are usually over 50 years of age, when there is some impairment of the adjustment of growth and repair. Parasitic diseases on the other hand usually attack young people more readily than old. The local infectivity of cancer does not necessarily indicate that it is parasitic. In the case of Thiersch grafts, epithelium detached from one site not only adheres to another but it grows readily, and the more sterile it is the better it thrives. A peculiarity of skin grafts is the stimulating effect which they exert on a wound surface, which reacts in an astonishing way, whether the graft "takes" or not. A vigorous superficial leucocytosis is set up, as if there were some peculiar vital influence exerted by the graft. In implantation cysts too we have a degree of new growth, which is fortunately limited.

In epithelioma there is greatly increased independence and growth as if a considerable mass of tissue had got away from some form of nervous control, which under ordinary condition counterbalances trophic influence. That injury may predispose to epithelioma is certain. Cicatrized areas subjected to irritation are far more liable to respon l than heathy tissue. Our knowledge requires to be advanced in the direction of a fuller acquaintance with the nerve control of the maintenance of the balance of epithelial growth and an investigation of the fluid by which these epithelial cells are nourished in health and malignant disease. In this relation the influence of the internal secretion of the ovary on mammary cancer is suggestive. The production of epithelioma by the administration of arsenic is also relevant and opposed to any parasitic theory of origin. Clinically the value of arsenic as a parasiticide is well established and it has been recently demonstrated anew in connection with the treatment of Trypanosomiasis and Syphilis. The influence of this drug too on the nervous system and on trophic processes, although little understood, is well known. That arsenic under certain conditions, should produce epithelioma supports a trophic theory of the origin of this disease.

Summary.—The kangri burn cancer is a typical squamous celled epithelioma. In the early stages the malignancy is slight, it is slow to infect glands and is very amenable to operation. In late cases deep glands are involved and often owing to adhesions and brawny infiltration of the skin and cellular tissue it is inoperable. In many cases its origin is in scar tissue. It is demonstrably due to a definite cause, *viz.*, irritation from the constant application of great heat. In this respect it falls into a line with other epitheliomata caused by mechanical, chemical or thermal irritation. The nature of the cause is opposed to a parasitic theory of origin and favours a trophic theory of the causation of cancer.

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DISCUSSION.

Major A. Street.—Can there be any special tendency in the males that they should show a double percentage over the females, though both the sexes are exposed to the same irritation.

Major V. Bennet.—It might be that the females do not seek the hospital aid.

Reply.—The clothing in females is more protective against the irritation.

EXCISION OF THE UPPER JAW.

By Major HENRY SMITH, I.M.S.,

Civil Surgeon, Jullundur, Punjab.

This is a subject which I think is worthy of consideration from the fact that, generally, I might almost say, invariably, the practise is to tie the external carotid artery with the object of reducing the amount of hæmorrhage and to do a laryngotomy and stuff the pharynx so as to prevent blood from making its way into the larynx and to facilitate the administration of an anæsthetic throughout the operation, as preliminary measures and safeguards. It is plain to any surgeon that when such precautions are necessary, the operator intends to spend a considerable amount of time over the operation—to do it in the present day leisurely fashion—as, if it were intended to do it in five minutes, none of these precautions would be necessary—yet with all these preliminary precautions the death-rate from the operation from (1) hæmorrhage, (2) shock, (3) aspiration pneumonia, and (4) what is not

included in the after-effects, a prolonged anæsthesia—is not under thirty per cent—a large butcher's bill in spite of these elaborate preliminary precautions.

I have up till the present done 43 excisions of the upper jaw without a single death, but my method is entirely different to the orthodox procedure above outlined, and such confidence have I in the results that I tackle an excision of the upper jaw with as much confidence as I do an amputation of the fore-arm. There is nothing to account for this difference in results but a difference in procedure. The procedure I hold to be correct in this operation and the one which I always practise is to do no preliminary operation, but to go at it direct and get it out in the minimum of time. My patient is chloroformed lying horizontally on the table, when he is fully under the chloroformist sits down and is no longer required. I, as rapidly as possible, make an incision from the upper lip which I do not cut through until later if at all; this incision runs up along the border of the nose to the flexure below the lower eyelid which it follows out to the zygomatic arch and with a few touches of the knife rapidly strip the soft tissues which I wish to save off the bone, but do not open the mouth at this stage. My assistant is clamping bleeding points and controlling hæmorrhage with sponge pressure at the same time. I drive into the spheno-maxillary fossa one blade of a bone forceps and bring the other blade on about the junction of the molar bone with the superior maxilla in the orbit and crunch what is in the grasp of the forceps through and with a twist of the forceps in that position, I dislocate that region of the jaw; I then slip a blade of the bone forceps up the nose and divide the maxillary attachment to the nose. I next open the mucuous membrane of the mouth as far as required, my assistant controlling all oozing from the face with sponge pressure. I then extract the incisor tooth in whose line I intend to cut the palate and cut the palate with one crush of the forceps; at this stage I separate the soft palate behind with one sweep of the knife and seize the jaw with a lion forceps over the region of the last molar tooth and near the molar bone and wrench it out; this is the position in which to catch it with the lion forceps as it is the most resistant and hence it does not break up in the forceps. From the time I lay on the knife first until I am putting in the stitches seldom occupies more than five minutes. From the moment I open into the mouth by cutting the mucous membrane, my assistant holds the patient's head, so that the blood will run out of his mouth until I have finished. The chloroform is all given before I commence operating and the patient is coming to when I am putting in the stitches. If any fragments of bone remain after the body of it is out I tear them out and never cut in that region with a knife or scissors. I have often drawn the attention of professional visitors to the fact that the moment the jaw is wrenched out bleeding practically ceases. I have never had to tie or twist a single vessel in this operation except the coronary artery of the lip. The only vessel that gives a little trouble is the vessel right back in the region of the pterygoid fossa. To control oozing I have got a few hot water cauteries made of solid steel with a wooden handle on one end and a spherical knob on the other varying from the size of a 10 bore bullet to the size of a ·450 spherical bullet—the shank about 7/16 inch in diameter and about 8 inches long. These are standing in a vessel of water kept boiling and are reached to me when required. They have the great advantage over all hot sponge methods of applying heat in that: (1) they are dry and hot water does not spread where we do not want it, (2) we can apply them to the exact point we wish, (3) they are at 212° F. and not more, (4) they are simple and rapidly heated.

The astonishingly small loss of blood in this operation when done thus is due to doing all bone cutting with forceps and to doing the operation rapidly. The vessels which are thus injured by the bone forceps and which are torn across do not bleed, but once the operator commences to dissect out fragments of bone from the cavity with a knife or scissors he observes that bleeding will at once become troublesome.

This is one of the operations which still call for a dexterous and rapid operator—the dexterity and rapidity of pre-chloroform days. The man who intends to spend from half an hour to an hour and-a-half at this operation requires all the preliminary precautions of the present day fashion and still his results will be very bad as shown by the statistics of the results of this operation. To tie the external carotid properly is not the rapid procedure its advocates would have us believe. True, it is easy to tie the external carotid rapidly if we have no respect for the plexus of veins which cross over it from the front and above—the plexus which drains this region. If we injure these veins we have much venous oozing afterwards in the jaw area which leaves matters in this respect as troublesome as if we had not tied the external carotid. Arterial bleeding is easily controlled but venous bleeding always requires a ligature: a torn artery gives little or no trouble from bleeding but a torn vein always does give trouble from bleeding until it is ligatured. A laryngotomy is a simple operation and so is stuffing of the pharynx. But stuffing of the pharynx in my observation should be thoroughly done when done at all and even then it is very liable to be shifted out of position by the movements of the larynx which a laryngotomy of course does not stop and when the stuffing is depended on to prevent blood entering the larynx it is thus far from being the reliable thing, it is generally thought to be. If it becomes in the least loose it acts in a sinister way by directing the blood into the larynx which would normally make its way into the stomach—a harmless place—and hence aspiration pneumonia. It is very much safer in my opinion for those who do a laryngotomy to not stuff the pharynx and to depend on their assistant holding the patient's head so that the blood will run out of his mouth and nose and to let any that may chance to get into the pharynx make its way to the stomach in natural fashion. A thing I have often observed in operations in this region when the tongue is not interfered with is that the soft palate while breathing under anæsthesia always—assuming that the

nose is not obstructed—lies close down on the base of the tongue shutting off the mouth from the pharynx, so that it does not take much inclination of the head to make the easy route for blood to be outwards; of course, bleeding into the nose will reach the pharynx if the head be not held well over but in this operation when this stage is reached a few seconds finishes the removal of the jaw. How often do we see patients after operation affecting the mouth or nose vomit blood after they come from under the anæsthetic, and how seldom do we see these patients have aspiration pneumonia? This is very strong evidence of the fact that if the pharynx and larynx be not interfered with blood entering the pharynx goes to the stomach—the natural place for fluids and solids to go. If the procedure I advocate were adopted I have little doubt we would cease to hear of aspiration pneumonia in these cases. We would also cease to hear of death from loss of blood and from shock as the loss of blood in this operation done, as I advocate, is trifling, and equally trifling seems to be the shock. If the operator fears a little loss of blood and secures every point as he goes along he will undoubtedly have a multiplicity of points to secure and he will be certain to have very much more loss of blood than the man who goes ahead and leaves bleeding to be taken care of by his assistant. The knife and scissors and the saw should be used a little as possible and the bone forceps used to the maximum of its capacity; what is cut with the knife scissors and saw bleeds freely; what is cut with the bone forceps hardly bleeds at all and they cut in this operation as cleanly and as well as any other weapon and have the tremendous advantage of being rapid.

True it is that the man who tackles an upper jaw, as I advocate, must have confidence in himself and be a dexterous operator and he must have a competent assistant.

DISCUSSION.

Major V. Bennet.—Cannot the hoisting out of the bone do damage to the eye and other structures?

Major A. Street.—Very few perhaps ligature the external carotid. As regards trachœotomy the main object is to prevent blood entering the trachœa, at the same time allowing further administration of chloroform; but as Major Smith removes the tumour with a twist without prolonging the anæsthesia, trachæotomy does not seem necessary. But for malignant growths, I am sure a wider cutting operation is essential, chloroform thus being essential.

Dr. Nanavatti agreed with Major Street that the knife must be used when the infiltration has extended much; and remarked that trachæotomy is not essential, as blood can be prevented from entering the trachæa by proper management of the head.

Major H. Smith's reply.—My paper implied malignant growths of the upper jaw. I have never had to excise the whole of an upper jaw for anything but malignant disease. Some speakers have referred to the statements I made regarding the death-rate and regarding the procedure adopted generally by surgeons as not representing the facts of the present day. Those statements I made on the authority of the recent edition of Jacobson's 2-volume book on surgical operations which I presume is representative of the present day as far as the upper jaw is concerned.

EXCISION OF THE GASSERIAN GANGLION.

By Major HENRY SMITH, I.M.S.,

Civil Surgeon, Jullundur, Punjab.

I have done this operation on six patients with one death, for epileptiform neuralgia of the fifth nerve.

Before I commenced I explored the region frequently on the dead body and easily persuaded myself that Rose's original route did not give room enough. I also persuaded myself that the high route—the Hartley-Krause route—did not give as easy access to the structures as I would like, the opening in the bone being 1¼ inches distant from the structures. It seemed to me that the Cushing route was much preferable to either and that if we extended Cushing's opening into the skull as far down as would open the foramen ovale we would facilitate access to the structures still more.

Rose's original route was through a trephine hole made below the pterygoid ridge. The Hartley-Krause route is above the level of the zygoma, a bone which in that route is not cut, and as the temporal muscle is detached from the skull and drawn down over the zygoma the operation is necessarily deep and well above that bone. In it we have to work in a small and deep space hampered with the difficulty in keeping the region clear of blood continually oozing from the detached dura mater, rendering it both tedious, and difficult to see exactly what we are doing in an operation in which it is absolutely essential to see exactly what we are doing. By Cushing's route we turn down the zygoma and make a 3 cm. hole which includes the pterygoid ridge. This opening to my fancy does not give room enough. There seems to me too much timidity about making a sufficient sized opening in the bone in Cushing's method—a photograph with notes at the end of this paper shows how little fear we may have about removing a considerable piece of bone from the skull. To overcome these difficulties as far as possible I make an H shaped incision, the cross bar of the H being along the zygoma. I cut the zygomatic arch as far back as will avoid opening the temporo-maxillary joint and at the other end at the very front of the arch and then turn down the masseter and attached zygoma and part of the malar bone. To get the temporal muscle as much out of the way as possible I cut the coronoid process off the lower jaw and turn the temporal muscle upwards. I strip the bone bare of periosteum with a raspatory over an area 1½ inches above the pterygoid ridge and also the crest and the region below the crest as far as the foramen

ovale. In detaching the periostium below the pterygoid ridge it is necessary to keep close to the skull so as to avoid the pterygoid plexus of veins, a plexus which if injured gives much trouble in bleeding, and to press well down the soft tissues below the pterygoid ridge as much out of the way as possible. When all bleeding outside the skull is controlled I take a square piece out of the bone above the pterygoid ridge $1\frac{1}{4} \times 1\frac{1}{4}$ inches and from this opening I separate the dura mater downwards and with a skull forceps enlarge the opening downwards. My objective points, the foramen rotundum and foramen ovale, being searched for by a blunt pointed hook as I go along, until I have opened as near the foramen rotundum as the pterygoid process will admit of the forceps biting. Having thus defined the foramen rotundum I proceed backwards with the foramen ovale defined by a blunt hook and open it freely from the outside and front. I then get my blunt hook over the superior maxillary division of the nerve close to the foramen rotundum. It is in this position easily defined. By pulling on it with the blunt hook I define it backwards through its sheath of dura mater and split the sheath along the nerve cord thus made tense with the point of a Graefe's knife as far as the ganglion and dislocate it out of its sheath with the blunt hook as far as the ganglion and put a ligature on it to be used as a tractor. I next isolate the inferior division with the hook just below the skull and split its capsule from below the skull up through the foramen ovale to meet the middle division which has been similarly treated and dislocate it out of its sheath in the foramen ovale and above it and put a ligature on the isolated nerve. I have thus got a tractor on each nerve which allows me to draw the ganglion forward by the nerve cords and with a few touches of the Graefe's knife to enlarge the opening in the dura mater over the ganglion and separate the attachments between the two so as to admit of the ganglion coming forward. When thus drawn forward out of its sheath I slice off the base of the ganglion to which the two nerves are attached with a Graefe's knife and extract the nerves peripherally with forceps as far as I can. Some cerebro-spinal fluid always escapes from this opening.

The opening made in the skull is practically a combination of Rose's original opening and of the Hartley-Krause opening. The advocates of the latter opening say that it gives enough room : my objection to it is that it does not give enough room. We cannot get too much room in this region. The inferior division of the nerve does not exist inside the skull as the ganglion lies over the foramen ovale and the nerve really commences at the inner opening of the foramen ovale. It is thus a very great advantage to get hold of the nerve below the skull and to isolate it up through the foramen. By this procedure the middle meningeal vessels are exposed on the dura mater right back to the foramen spinosum, and if it is necessary to deal with them on account of injury they can be lifted on the needle through the dura, and, to deal with them in the neighbourhood of the foramen spinosum, I simply pack it tightly with a stout silk thread, the tail of the thread being left long out of the wound, to be drawn out the following day. I do not tie any vessel until it is injured. If this procedure be adopted there is no reason why in all ordinary cases we should tie the middle meningeal vessels between two ligatures after they leave the foramen spinosum as they should not be injured. To tie these vessels by the Hartley-Krause route is no simple matter as they are so far off and the continuous oozing which makes the operation so tedious obscures the view. It is very much easier to deal with them through the route I advocate. It is also very much easier to keep the field sponged and visible through my route.

By the Hartley-Krause and Cushing routes the inferior division is cut inside the skull after which there is only the middle division to be used as a tractor. Let anyone do this operation on the dead body and he will at once see the advantage of being able to use the inferior division as a tractor also.

The advocates of the high route seem to object to any invasion of the site of Rose's original opening as if it were "forbidden" ground—why it is difficult to understand. They say the high route does not cause fixing of the jaw and is not followed by necrosis of the zygoma. The deformity is constant in any route. When the zygoma is left the muscles all atrophy and leave the arch standing out as a prominent ridge. I remove the zygoma and the coronoid process of the lower jaw and thus make sure that they will not necrose and I stitch the masseter to the temporal muscle. Necrosis occurred once with me. I have no doubt that the flat side of the face resulting is no greater deformity than the prominent zygomatic ridge left after the Hartley-Krause operation. Stiffness of the lower jaw did not occur in any of my cases. They say we may open the Eustachian tube and thus get septic infection, a thing which has apparently occurred. If ordinary care be taken this should never occur ; neither should opening of the cavernous sinus ever happen. No operation can be devised which will safeguard everyone against all possible accidents.

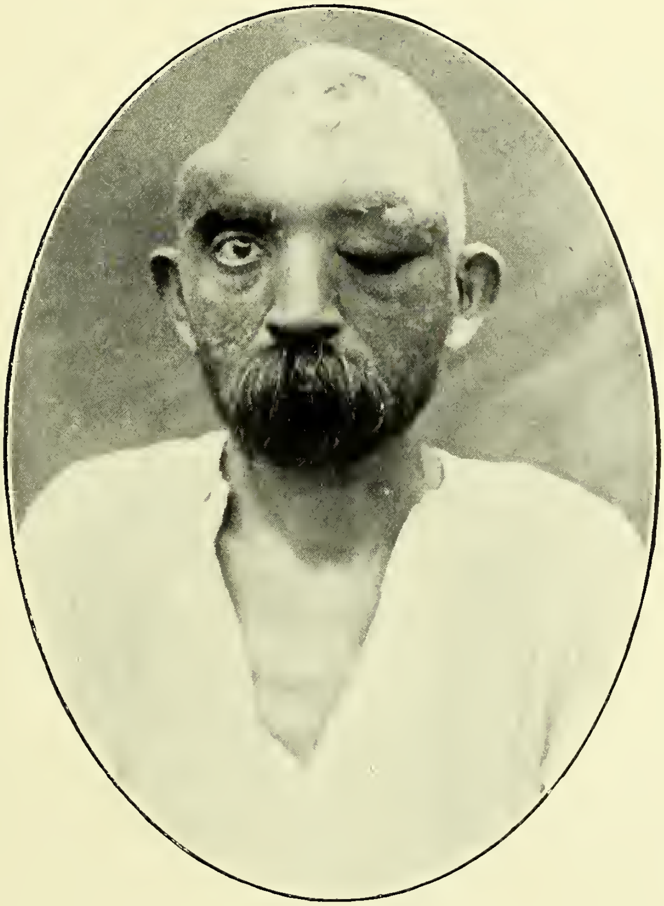
I tied the external carotid in one case but am not certain that it much facilitated matters. If tied it should be very carefully done so as not to obstruct any of the veins draining the area of operation ; it is venous oozing which causes so much delay in this operation. My one death was due to the amount of blood lost from the continuous oozing from the region. In my cases it was not necessary to remove the whole of the ganglion as the superior division of the nerve was not affected.

The results so far as I have been able to follow them have been satisfactory.

I place one end of a strip of gauze in contact with the dura mater and bring the other end out of the wound to drain all oozing for 24 hours leaving an untied stitch to be tied when the gauze has been removed.

I might here make a note of a case of neurectomy. This man had an area of tic of the upper lip about half an inch in diameter. It was to all appearance as troublesome to him as if his whole face had been involved. I opened up the infraorbital canal and drew out the nerve

Excision of the Gasserian Ganglion.



apparently as far as the base of the skull and drew out its peripheral branches as well. He had complete relief for about two years. I opened up the same region a second time and found the same full sized nerve present. I extracted it as before and this was again followed by two years' relief. I did the same again in April 1908 with the same result so far.

The photograph attached to this paper is an indication of how much skull may be removed with impunity. The patient came to me four years ago with syphilitic necrosis of the skull. I removed the whole frontal bone above the brow, the whole right parietal and about half the left parietal, scraped the dura mater and the under surface of the scalp and dressed him up with gauze drainage. He left hospital in ordinary course completely healed up. He came back to me in April 1908 with an abscess beneath the eyebrow and a sinus further back. I explored the region and chipped away a point of superabundant callus over a sinus communicating with the abscess. There was practically no effort of nature to replace the bone removed, the brain could be felt pulsating over the whole area. The man is a clerk in a railway office and suffers no inconvenience. Nature in such instances teaches us how little we need fear removing a large piece of skull when we wish to get freely at such a difficult region as that of the Gasserian Ganglion.

THE SURGICAL TREATMENT OF DISEASED LYMPHATIC GLANDS OF THE NECK AND AXILLA.

By Major HENRY SMITH, I.M.S.,

Civil Surgeon, Jullundur, Punjab.

From the fact that the thorough removal of diseased glands from these regions is rarely done, that the necessity for thorough removal from these regions once the surgeon has to interfere is recognised by few, from the variety of incisions used to remove diseased glands from the neck and from the injuries incident to important structures from removal through some of these incisions, I think the subject is worthy of more consideration than it usually receives. To a novice the complete removal of all the glands from one side of the neck is one of the most formidable and dangerous operations in surgery. These patients generally take chloroform admirably and do not seem to suffer as much from prolonged anæsthetization as patients do in many other operations. A fact I once observed in the removal of tubercular glands from the neck was to me interesting: the girl had slight evidence of tubercle of the corresponding lung; everything went well until about a fortnight after the patient left hospital when she was seized with acute miliary tubercle of the lung which caused her death in a few days. What I would be interested to know, and to have the opinions of others on is, did the removal of the glands in the neck contribute to the onset of the acute tuberculosis? I am rather disposed to think that it did. We all know when we remove a few tubercular glands from the neck that the glands left behind take on a more active development than if we had not interfered. I have noticed the same in the case of malignant disease of the glands of the neck; those left progress more rapidly than if we had not interfered.

The practice I now advocate after an experience of some hundreds of cases of extirpation of diseased glands in these regions is that if we have to interfere surgically we should remove all the glands from the diseased side of the neck or axilla for tubercle as clean as if we were dealing with cancerous glands of those regions. If we leave any, even though they do not seem diseased, they very soon become tubercular and we are called on to do a further or a number of further operations for their treatment. This is a very marked fact in my experience. I suppose I am right in thinking that when the surgeon at the present day has to interfere for those conditions that there is only one recognised method of treatment, *viz.*, the complete removal of the diseased structures and that opening scraping and draining when they have reached the stage of abscess is relegated to the history of the past of surgical procedures and correctly so. In dealing with the neck the submaxillary and submental glands can only be reached by an incision in those regions. Apart from these glands, to reach from the base of the skull to the collar bone, some advocate an incision along the front of the sterno-mastoid muscle, some this incision along with cutting the sterno-mastoid muscle across in the middle of the neck, and some, with these incisions, the ligaturing and cutting of the internal jugular vein on the grounds of safety and rapidity. To cut the muscle thus should be unnecessary and is certain to leave an unsightly scar and depression over the region, as a muscle thus cut never unites except by fibrous tissue. The incision in front of the sterno-mastoid muscle does not give access to the glands in the posterior triangle of the neck and gives poor access to the glands under the angle of the jaw and over the great vessels close to the base of the skull. It is thus of limited range. In it the lower branches of the facial nerve are very liable to be cut. It thus is not the incision from which to remove anything but a few glands and leaves the important group in the posterior triangle untouched; in short the incision allows for

only a partial removal of the glands of the neck. The ligaturing and cutting of the internal jugular vein unless when injured is a mutilating and unnecessary procedure. This vessel drains practically half of the interior of the skull, the brain included. How will the patient whose internal jugular of one side of the neck has been thus treated fare at a later date when the other side of the neck comes to be dealt with, as is so often the case, if that vein happens to be injured as occasionally happens in the hands of the most skilful, and has also to be ligatured of necessity? Does ligaturing the internal jugular vein thus facilitate the performance of the operation? I don't think it does. Is ligaturing the internal jugular vein thus a safeguard against air entering it? Quite otherwise. If the slightest tear be made in the internal jugular or its emmissaries close to it below such ligature such as may happen in removal of glands from its immediate neighbourhood air is almost certain to enter and to end the scene. During this operation the internal jugular is always full of blood and when opened blood flows out and air cannot enter, but once ligatured the conditions are reversed and the entrance of air is facilitated as much as we can facilitate it. It is thus on this account also a procedure to be sedulously avoided and here I am speaking from bitter experience as I shall note later on.

I shall now deal with the procedure which I adopt and which from experience I have come to regard as the best.

The instruments I use are sponges *nil*, a scalpel, a few pairs of artery forceps—pressure—a Volkman's spoon, needles, sutures, ligatures, scissors and occasionally a retractor. Instead of sponges my assistant washes away blood or glands which have ruptured with a stream of warm 1 in 2,000 bichloride of mercury solution from an irrigator suspended above the table. The best gland forceps are those which I use, *viz.*, the fingers. My incision extends from the skull just behind the attachment of the sterno-mastoid muscle to the collar bone cutting behind and just avoiding the external jugular vein. The only thing we have to take care of in the posterior triangle is the spinal accessory nerve; any vessels cut in this region are not of much importance and are ligatured when cut. I then reflect back the skin and dissect the glands and cellular tissue in which they are imbedded from behind as far forward as my incision. I next shove my finger across along the upper border of the collar bone and with it draw out the glands and cellular tissue containing them from the internal jugular vein and weed them from it with the fingers of my two hands. This is the region of the neck in which the glands are loosest and in consequence the region in which the internal jugular vein is most easily exposed. In this region there are often a few glands on the top of the pleura which require to be very carefully weeded of it so as to avoid opening it—I have thus opened it twice without ill effects—the cases I will relate later on—those glands which lie on the pleura are almost always pigmented a dark colour. In this operation it is very important to thoroughly expose the internal jugular vein as early as possible. It is easily exposed low down in the neck and exceedingly difficult to expose from the posterior triangle high up owing to the dense adhesions of the glands. Once I expose the internal jugular vein low down I proceed to separate it from the glands with my fingers—never with the knife—which is quite easily and rapidly done. When I have it quite separated for an inch or so upwards I dissect the glands and cellular tissue up that far and separate it a further inch and so on. When the posterior chain and the glands lying on the jugular are cleared out I proceed to remove those beyond it from the same incision including the one in the suprasternal notch and the gland or two which lie beyond it below the angle of the jaw. To get at the gland on the outer surface of the sterno-mastoid and in the parotid gland below the ear I split the sternomastoid from beneath and press the gland through the wound and then expose through that wound the gland below the ear and draw it out with a large Volkman's spoon. If any tributaries of the internal jugular vein be torn, which fairly frequently occurs with those in the upper section of it, they are ligatured; and if any small tear be made in the main vessel I clip it with a forceps and put a ligature on the side of it. I have had to ligature the main trunk on but two occasions. When the glands are out and we proceed to ligature branches of veins we should always press the vein below before taking off the forceps so as to fill it and thus make sure that we have left it water tight. It is in my experience very seldom that we have to tie any arteries the transverse cervical being the most frequent. If the gland or two resting on the pleura are at all difficult to remove we should leave them till last owing to the chance of opening the pleura in their removal. This accident happened to me twice and on each occasion they were large pigmented glands and firmly adherent to the pleura. Air in these cases was admitted freely to the pleural sac; my assistant pressed on the region from the outside of the skin and I sewed up the wound as usual without a drain and all went well.

I have had one case in which air entered the internal jugular vein with the usual fatal result—the only death which I have had in the removal of diseased glands. It was as follows:—a case of densely matted glands; I had torn off the tributaries low down and clamped them with forceps; I had made a large tear in the main trunk in the middle of the neck which I clamped, applied two ligatures and cut between them. It was a tedious case and the patient was not taking the anæsthetic well. When I had finished with the glands I proceeded to dispose of the vessels I had clamped from above downwards letting what seemed unimportant go without a ligature as usual. I assumed a little stump of vein below the ligature was of no importance and let it go similarly; the patient opened and closed her mouth a few times just as a fish does when it gasps when taken out of water and she was dead. There are few of such cases recorded though they are not as infrequent as the records would lead us to believe; their records are buried with their bones. It is from this case that I am very strongly of opinion that it is bad surgery to tie the main trunk if it can be helped. From it also I regard it as all important to commence

operating on glands as low down as possible and working from below upwards so that if we are obliged to tie the main trunk there will be no risk of tearing it or its tributaries below the seat of ligature, *i.e.*, tearing it where it is empty and where the tear will be certain to allow air to be sucked in. When its tributaries are tied we should always obstruct the vein below before we remove the forceps so as to make sure that the ligature has secured the bleeding point. All tributaries when torn should be ligatured. I have frequently made a tear in the main trunk which I have seen no ill effects from ; such tears bleed freely—very freely. Under normal conditions in this operation the vein is always full of blood ; while full of blood a tear will bleed freely and cannot admit air, *not so a tear below a ligature on it.* If glands are suppurating in the neck or in any other region with sinuses I never hesitate to clear out the neck. My procedure in these cases is to avoid the diseased skin area or sinuses with my incision and to remove the glands from behind where their capsule is not matted and to dissect out the sinuses and diseased skin and to stitch up without drainage and they do admirably.

A word for the mercury douche in preference to sponges. While I am as strong a believer in aseptic surgery as any man, I am a little too practical to attempt it with our usual Indian district hospital surroundings. It is complicated, it is expensive, and there are so many points in it which if not perfect bring us in results which are a near approach to pre-Listerian days. To have it perfect with our Indian staff in district hospitals is more than I could dream of. It is for this reason that in general surgery I have almost entirely discarded sponges, swabs and sponge towels, and when I do use such things they are prepared before myself. Since I substituted a sublimate douche for such things it is rare for me to see even a stitch abscess and I very seldom drain wounds. As regards drains my policy is to not drain when in doubt. My observation is that if we drain we find that there will be something to drain before we have finished.

The incision in the posterior triangle gives much more room than the one in front of the sterno-mastoid as it reaches from two to three inches higher and thus has the great advantage of thoroughly exposing the troublesome glands close to the base of the skull.

The Axilla.—When glands (tubercular) have to be removed from the axilla the same principle holds as in the neck—the whole group should be removed. To do this properly and rapidly an incision is made along the axillary border of the pectoralis major sweeping downwards below the group and backwards until it reaches the border of the latissimus dorsi. I then pass my hand right up between the axillary fascia and the chest wall to the apex of the axilla and bring down the whole axillary fascia and its contained glands and weed the axillary fascia and glands from the great vessels and nerves with the fingers of my two hands and finally clear the lot with a few touches of the knife from the convex flap of skin. The gland between the pectoralis major and minor I similarly isolate with my fingers. There are a few points of veins torn which require ligaturing. By this method the most troublesome case is thoroughly done in a few minutes and the skin may be safely sewed up without a drain if all oozing is thoroughly stopped, and the patient is all right in a few days and never consults us again concerning glands in that axilla. The practice of opening tubercular abscesses and draining them or of dissecting out individual glands in this region is bad surgery, as the case goes on time after time with great inconvenience to the patient until nature destroys them all or until when they are all dissected out.

SPINAL ANALGESIA.

With Notes on 31 Cases.

By Capt. A. CHALMERS, I.M.S.

Substance used for injection.—A. E. Barker's 1 per cent. Stovaine, 5 per cent. glucose, and Water 83 per cent. The *needle* employed was that known as "The Record"—in this needle nickel is used as it is durable and does not rust. The *dose* was 2 c.c. in all but one case where only 1 c.c. was used. As regards *technique* the important points are—

1. *Perfect asepsis.*—This is secured by using a special steriliser supplied with the needle and using this steriliser for this purpose and no other. Distilled water is used in the steriliser. The skin is cleansed and finally washed with normal saline and finally with sterile distilled water.
2. *Position of the Patient*—If a high analgesia is required the injection is done with the patient lying on his side with his head and pelvis elevated (the head should of course be the highest point). The patient draws his knees up to his head and bends his head well down. As soon as the injection is over he is gently and slowly rolled on to his back unless one sided analgesia is required when that side is kept lowest for some minutes. In ordinary cases requiring a low analgesia such as hydrocele or fistula in ano, the injection is done with the patient sitting up and leaning well forward over one side of the table.
3. *Definition of site of puncture*—Best done by two fingers of the left hand one on each spinous process adjacent to the selected interspace—

the line given by some authorities between highest point of the Iliac Crests being a useful guide. The needle is thrust in with a stab-like movement, the quicker done the less the pain; it is then pushed on till the resistance is felt to lessen when the stylet is withdrawn and the hollow needle pushed in till one feels a sensation like pricking a drum and the cerebro spinal-fluid flows out rapidly in drops or continuously. If it comes out *slowly* one may revolve the needle slightly and if this fails another puncture may be tried or the attempt abandoned. The Stovaine should be injected slowly. The hollow needle with canula attached is then withdrawn in one piece, the puncture sealed with Collodion and the *patient moved as little as possible*. The first symptom noticed is usually numbness in the feet and legs—paralysis soon follows and generally analgesia is complete inside 6 minutes and often sooner.

4. The patient's head must be kept elevated during the operation and for some hours afterwards.

Complications and Sequelæ.

Among the former may be classed—

(1) Faintness, (2) Nausea, (3) Vomiting.

Among the 31 cases—

(1) *Faintness* was noticed in 3 cases. It was on no occasion more than temporary and there was no evidence of any after-action on the heart. It was readily benefited by hot coffee and brandy which I always have ready by me.

(2) *Nausea.*—Present in 2 cases. Soon passed off in each case.

(4) *Vomiting.*—In one case, a nervous man of 25, who nearly fainted when he felt the prick of the needle; it was bilious in character and did not come on till 20 minutes after injection.

Among Sequelæ may be mentioned—

(1) *Headache*—Coming on shortly after operation and lasting from a few hours to 8, which was the longest in my series; present in 6 cases.

(2) *Nausea.*—In one case.

(3) *Vomiting.*—In one case, severe and persistent, accompanied by retching and salivation; lasted 48 hours; due, I imagine, to patient's head having been lowered inadvertently. (It was my first case in Madras).

(4) *Pains in lower extremities.*—Rather severe, lasted 12 hours, Morphia necessary. The patient left hospital perfectly well 8 days later.

Results of injection :—

Perfect Analgesia in 25 cases.

Failure, complete, in 1 case.

Failure, *partial*, in 5 cases.

In each of the 5 partial failures the patient afterwards made little of the experience, but in 2 cases chloroform was necessary.

Number of punctures.—One puncture in 29, two punctures in one case (my first case), three punctures in one case—a hunchback.

Flow of cerebro-spinal fluid—rapid drops in 30 and slow in 1.

In the last case the result was complete failure. I will now mention the 31 cases with details where necessary.

Case 1.—*Infective Granuloma of Vulva*—Entered canal at second puncture—spinal fluid flowed in rapid drops–6 c cm. removed. Analgesia up to iliac crests in four minutes. Loss of all reflexes up to this level. Motor paralysis ditto. Patient quite comfortable. Analgesia lasted 1 hour and 25 minutes. After-effects *nil* except slight headache. Patient had had $C\ H\ Cl_3$ previously and said she preferred this method. (2 c.cm. of Stovaine and Glucose injected.) Anæsthesia was perfect, deep dissection and thermo-cautery.

Case 2.—*Amputation of Penis for Cancer.*—Male, aged 65—weak—c. s. fluid escaped in rapid drops, one drachm removed—2 c. c. of Stovaine sol. injected. Analgesia in 3 minutes—operation began after 4½ minutes; slight sensation on cutting suspensory ligament. Otherwise satisfactory. Duration of analgesia 50 minutes. No after-effects except slight headache which lasted 6 hours, but was never severe.

Case 3.—*Hydrocele.*—Radical cure—size of a cocoanut. Analgesia in 4 minutes in scrotum and perineum up to a s. s. in 8 minutes. Duration of analgesia 65 minutes. No after-effects. Injected in sitting posture laid flat on back with head well raised. Patient was astonished to find operation completed.

Case 4.—This was a curious case. Patient, a male, aged 58, complained of severe pain in the scar of an old operation; wound situated over linea alba above umbilicus in which was a small discharging sinus. There was much thickening and the mass felt like a tumor. On cutting down a hard substance was felt, and this proved to be the ends of an old silver wire suture embedded in the abdominal muscles. The ends were untwisted, cut with pliers and the wire removed—the wire was nine inches long (No. 7 thickness). The track was cleaned and swabbed with Zn Cl2.

This patient was turned on his back at once after injection with his hips and head elevated. Anæsthesia complete up to epigastrium. The wire had been inserted 15 years ago by Colonel———, I.M.S., in Hyderabad. No after-effects.

Case 5.—*Removal of Extensive Cancerous Glands in both groins.*—Laid on back with hips and head well elevated. Complete analgesia up to a. s. s. in 8 minutes; very large and deep dissection; operation lasted one hour, analgesia passed off in 1 hour and 50 minutes. No after-effects.

Case 6.—*Hydrocele.*—Radical cure; result perfect; no after-effects.

Case 7.—*Hydrocele*, R.—Radical cure. A very nervous patient of 23 years, nearly fainted when needle introduced. *Bilious vomiting 20 minutes after injection* just as oper-

ation was completed. Had rather severe headache for 3 hours.

Case 8.—*Hydrocele*—Size of very big cocoanut; second puncture necessary—had the least inconvenience, and although patient was nervous he was delighted with result. No after-effects.

Case 9.—*Large R. Hydrocele.*—Size of a large cocoanut. Puncture made with patient sitting up; rapid escape of cerebro-spinal fluid ℥iss withdrawn—2 c. c. of Stovaine sol. injected. Patient turned on right side with head and buttocks elevated. Operation begun 4 minutes after injection; perfect result; no complaints and patient was loud in his praises of the method. Analgesia up to 1″ below umbilicus. No after-effects.

Case 10—*Elephantoid Vulva*—Woman aged 40. The analgesia was rather slow in developing in this case; no motor paralysis till 10 minutes had elapsed; operation started 4 minutes after injection. There was no ill-effect except a slight headache; result very satisfactory; 2 c. c. injected as usual; patient laid on her back, after injection made in sitting posture. Upper limit of analgesia was lying between ant. sup. iliac spines.

Case 11.—Removal of suspected malignant tumor from L. groin of a woman aged 40. This woman had been operated on some months ago for an infective granuloma of vulva (removed under spinal analgesia). The parts had healed, but the inguinal and femoral glands were enlarged and tender. Free incision from spine of pubes to ant. sup. iliac spine and tumor dissected out with glands, etc. Result very good, but patient was very nervous and had, or at least she thought she had, slight pain near the close of operation.

In this case the patient was turned on her left side and the injection made in that position. Analgesia up to mid-way between umbilicus and epigastrium. No after-effects; patient quite pleased.

Case 12.—Radical cure, L. Inguinal Hernia—man aged 25, very nervous and complained of the puncture; injection with patient on left side and buttocks elevated. Analgesia up to epigastric notch in 6 minutes. Patient suffered from nausea and felt faint for a few minutes (3 minutes after injection), given hot coffee with brandy which relieved him. Operation begun 5 minutes after injection quite satisfactory till skin sutures inserted when he felt slight uneasiness not amounting to actual pain. Operation lasted 45 minutes. Bassini's method.

These results have encouraged me as to the safety and efficacy of the procedure, and I hope to publish a further set of results shortly. The necessary outfit consisting of Record Syringe in nickel case and steriliser can be got from Krohnet Legeman, London, for about Rs. 40.

Case 13.—Operations for Necrosis of Tibia, boy, aged 11, 1 c.c. given—excellent result.

Case 14.—Operation for prolapsed uterine fibroid—immediate result good—*died* of Pulmonary Embolism on 3rd day—had all classical symptoms—no *post mortem* allowed.

Case 15.—*Hydrocele.* Rad. cure—immediate result good, severe and persistent vomiting for 48 hours—quite well on the third day.

Case 16.—Castration—old man 65 years—good result.

Case 17.—*Hydrocele*—good result. Slight headache as sequela.

Case 18.—Peritonitis—(advanced general)—girl of 11 years in a very bad state—distended abdomen, facies characteristic—2 c. c. injected, died on table soon after abdomen was opened; in fairness to the stovaine, I do not consider the result was due to this drug as the girl's condition was so desperate I hesitated to give $CHCl_3$.

Case 19.—Elephantiasis of right thigh—excellent result.

Case 20.—Strangulated Hernia—man with double disease and enlarged heart in a bad state—result excellent—pulse better after operation.

Case 21.—Elephantoid Scrotum—excellent result, save very slight faintness for a few seconds.

Case 22.—*Castration*—failed to get analgesia (C. S. fluid escaped only in slow drops).

Case 23.—Hernia—radical cure, immediate result good. Sequelæ—slight headache and rather bad pain in both lower extremities for some hours.

Case 24.—*Double Hydrocele*—Radical cure—excellent result.

Case 25.—*Strangulated Hernia*—man, aged 55, in a bad way—no time for radical cure—result excellent, no after-effects.

Case 26.—*Double Hydrocele*—(private case) said he felt dragging in his Scrotum, but no pain—no after-effects.

Case 27.—Prolapse of Rectum (complete).—Excision—excellent result.

Case 28.—Castration for Tubercular testicle—very nervous man—said he felt pain and had ʒI $CHCl_3$, confessed next day that he had not felt pain, but was in fear of doing so "as he got no gas."

Case 29.—Elephantiasis of Scrotum and Penis—had been previously operated on for double Hydrocele and the testicles were enucleated only after a long and tedious dissection—pain after 30 minutes ʒI $CHCl_3$ used—no sequelæ.

Case 30.—Fistula in Ano (private case)—very chronic with multiple sinuses—excellent result, patient delighted.

Case 31.—Operation for Hypospadias (private case), result very good—no sequelæ.

On the whole the results are encouraging and I think that with more experience far better results are to be expected. I have traced 3 of the patients for several months and all are in excellent health.

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RAO SAHIB A.K. PAI, B.A.

This Section comprised the Congress Exhibition held on the open space opposite the University Buildings known as the Oval. The Exhibition consisted generally of exhibits of medical, surgical, sanitary, building, ventilating, disinfecting and fumigating appliances, etc.; drugs, foods and toilet requisites ; hospital and operation room furniture ; model buildings ; models of insanitary and improved areas in Bombay ; scientific instruments ; medical and scientific publications, &c., &c.

During the Sessions the Exhibition was only open to members of the Congress and subject to certain minor restrictions, to holders of free tickets (qualified Medical Men, Nurses and Senior Medical Students), and, in addition to the general exhibits, there was a Museum of pathological specimens in which were held series of demonstrations including microscopical and macroscopical specimens of pathological conditions, micro-organisms and other parasites, disease carrying insects, etc.; diagrams; photographs ; paintings ; charts, etc., etc. The Museum was arranged and supervised by Captain Cunningham, I. M. S., of the Parel Laboratory who was aided in the work of arrangement by Captain Lloyd, I. M. S., of the Indian Museum, Mr. F. M. Howlett, Second Imperial Entomologist (Pusa), Captain Greig, I. M. S., Captain Beauchamp Williams, I. M. S., Hony. Asst. Surgeon Ramachandrier and others. Material was collected for the Museum, on the following principles, *viz.* :—

(*a*) That the specimens should be both of clinical and pathological interest, and that they should cover as much ground as possible.

(*b*) That they should be illustrative of affections for the most part peculiar to the tropics, though not exclusively Indian.

(*c*) That each lot of Exhibits should be in definite series, *e.g.*, the succession stages of the life-history of parasites, etc.

CATALOGUE OF EXHIBITS.

The following is the Catalogue of the Exhibits as issued to members of the Congress :—

I.—MALARIA—

(*a*) Various stages in the life-cycle of the following parasites :—
Benign tertian.
Quartan.
Malignant tertian.

By
The Bombay Bacteriological Laboratory.
Lieut.-Colonel Adie, I.M.S., Ferozepore.
Major Leonard Rogers, I.M.S., Calcutta.
Dr. Powell, Bombay.
Captain Wells, I.M.S., Bombay.

(*b*) Zygotes in the stomach wall of an infected mosquito.

By
The Bombay Bacteriological Laboratory.

(*c*) Mosquitos and their Larvæ.
Anopheles.
Culex.
Stegomyia.

By
F. M. Howlett, Esq., 2nd Imperial Entomologist, Pusa.

View of Exhibition from Messrs. Powell & Co.'s Model Operating Theatre
(Marked with cross on left hand side).

(*d*) Monkey Malaria.
By
Sleeping Sickness Commission, Uganda.
Captain E. D. W. Greig, I.M.S., Bombay.

II.—KALA AZAR—
Leishman Donavan Body—
(*a*) Cultural stages.
(*b*) Morbid appearances in various organs.
By
Major Leonard Rogers, I. M. S., Calcutta.

III.—DELHI BOIL—
Various cultural stages of a parasite found in the the sore.
By
Dr. R. Row, M.D. (London), Bombay.

IV.—ORIENTAL SORE—
Parasite found in an Arabian Oriental Sore.
By
Dr. N. F. Surveyor, Bombay.

V.—SLEEPING SICKNESS—
(*a*) Morbid appearances in the brain.
By
Captain E. D. W. Greig, I.M.S., Bombay.
(*b*) Glossina palpalis.
By
The Sleeping Sickness Commission, Uganda.
F. M. Howlett, Esq., Pusa.
(*c*) Trypanosome Gambiense.
By
Capt. E. D. W. Greig, I.M.S., Bombay.

VI.—TRYPANOSOMES—
Human.
Animal.
By.
Lieut.-Colonel Adie, I.M.S., Ferozepore.
Captain E. D. W. Greig, I.M.S., Bombay.
Captain Holmes, A.V.C., Muktesar.
L. H. Sowerby, Esq., I.C.V.S., Bombay.

VII.—BLACKWATER FEVER—
Spleen Smears.
By
Captain Christophers, I.M.S , of the Blackwater Fever Commission.

VIII.—SPIROCHAETES—
(*a*) Carteri—Indian Relapsing Fever—
(i) In Human Blood.
(ii) In the Louse (Pedicules Vestimenti).
By
Captain F. P. Mackie, I.M.S.
Lieut.-Colonel Adie, I. M. S.
(*b*) Other Spirochaetes—
(i) Human.
(ii) Animal.
By
The Bombay Bacteriological Laboratory.
Captain Markham Carter, I.M.S., Kasauli.
Dr. J. W. W. Stephens, Liverpool.
Dr. Powell, Bombay.

IX.—BLOOD-SUCKING INSECTS.
By
F. M. Howlett, Esq., 2nd Imperial Entomologist, Pusa.
(Detailed classification at the end of the Catalogue.)

X.—MYCETOMA—
Black, White and Red Varieties—
(*a*) Cultural and Microscopic Appearances.
By
Dr. F. M. Gibson, Madras.
Dr. Surveyor, Bombay.
(*b*) Macroscopic Appearances.
By
Agra Medical School.
Captain Powell Connor, I.M.S., Calcutta.
Asst. Surgeon J. Bocarro, Broach.

XI.—LEPROSY—
Von Deycke's Nastin Treatment—
(*a*) Effects Produced on the Leprosy Bacillus.
By
Captain Beauchamp Williams, I.M.S., Bushire.
(*b*) Morbid Appearances in Rats caused by an Acid Fast. Bacillus very similar to that of Leprosy.
By
Captain T. H. Gloster, I.M.S., Bombay.

XII.—NEGRI BODIES.
By
Major Cornwall, I.M.S., Coonoor.

XIII.—PLAGUE.—
(*a*) Fleas.
By
Captain W. G. Liston, I.M.S., Bombay.
(*b*) Plague Rats.
By
The Bombay Bacteriological Laboratory.
(*c*) Indian Rats.
By
Captain Lloyd, I.M.S., Indian Museum, Calcutta.

XIV.—DYSENTERY.—
Cultural Appearances of various Bacilli causing Dysentery, showing most recent methods of separation.
By
The Dysentery Inquiry Committee.
Captain Greig, I.M.S.
Captain Wells, I.M.S.

XV.—PARASITIC WORMS.
By
Dr. Powell, Bombay.

XVI.—LEUCOCYTOZOA.
By
Lieut.-Colonel Adie, I.M.S., Ferozepore.
Dr. C. A. Bentley, Bengal.

XVII.—VARIOUS PARASITES.—

(*a*) Coccidia.

By

Lieut.-Colonel Adie, I.M.S.
Captain Christophers, I.M.S.

(*b*) Mononuclear Parasite of Sparrow.

By

Lieut.-Colonel Adie, I.M.S.

(*c*) Yellow Body In Spleen, Pneumonia.

By

Lieut.-Colonel Adie, I.M.S.

(*d*) Piroplasmata.

By

Captain Holmes, A. V. C., Muktesar.

(*e*) Parasite of Cockroach.

By

Dr. Surveyor, Bombay.

XVIII.—MORBID GROWTHS AND APPEARANCES IN VARIOUS ORGANS.—

(*a*) Pulmonary Atheroma.

By

Major Leonard Rogers, I.M.S., Calcutta.

(*b*) Tumours of Interest.

By

Major Leonard Rogers, I.M.S., Calcutta.

(*c*) Undiagnosed Tumours.

Opinions as to diagnosis being invited.

By

The Bombay Bacteriological Laboratory.
Captain Ingram, I.M.S.,
And others.

XIX.—NAKED EYE SPECIMENS.

(*a*) Mounted Specimens.

By

Agra Medical School.
Grant Medical College, Bombay.

(*b*) Calculi.

By

Grant Medical College, Bombay.
Lieut.-Colonel Jennings, I.M.S.
Captain Ruzzak, I.M.S.

XX.—SNAKES—

Poisonous and Non-Poisonous—

(*a*) Preserved Specimens.

By

The Bombay Natural History Society.

(*b*) Illustrations.

By

Captain Fayrer, I.M.S.

ORDERS AND FAMILIES OF BLOOD-SUCKING INSECTS.

(*Prepared by Mr. F. M. Howlett to assist those who have not made a study of the subject.*)

Order DIPTERA (two-winged flies). GROUP A.—Body rather slender: antennæ long and often plumed, the joints usually numbering at least a dozen and having the general appearance of a string of roughly similar elongated beads.			
(1) Very small grey flies. Body and wings very hairy: resting position as in figure of *Phlebotomus*	Genus *Phlebotomus* Family *Psychodidæ*.*	"Sand-flies."	Breed in damp, dirty earth. Development of egg to fly takes about a month in hot weather.
(2) Very small dark-coloured flies, legs shorter and thicker than in (1), male antennæ bushy: proboscis short. Resting position as in figure of *Ceratopogon*	Genus *Ceratopogon* Family *Chironomidæ*	"Midges."	Breed in water, damp earth, or under bark, &c. Development about three weeks.
(3) Legs and proboscis long, body and wings clothed with scales. Male antennæ bushy. Resting positions as in figure of *Anopheline* and *Culicine*	Several genera Family *Culicidæ*.*	"Mosquitoes."	Breed in stagnant or nearly stagnant water. Development about a fortnight in hot weather.
GROUP B.—Body not slender, the thorax not flat and polished. Antennæ not long, or at any rate not looking like a string of similar elongated beads, nor like the antennæ of Group C.			
(1) Quite small, thick-bodied flies with faint wing-veins: antennal joints resembling a string of about ten very short beads so closely pressed together as to appear almost a solid cylinder. See figure *Simulium* ...	Genus *Simulium* Family *Simuliidæ*.	"Bull-flies," "Hill Sand-flies," "Potu flies."	Breed in hill streams and rapid torrents. Period of development not accurately known.
(2) Generally rather large flat-bodied flies with broad head and eyes coloured with green or purple bands or spots. Antennæ point straight ahead, rather variable in shape. Resting positions as in figures of *Tabanus*, *Hæmatopota*, *Chrysops* and *Pangonia* ...	Several genera Family *Tabanidæ*.*	"Dans-flies," "Clegs," "Gad-flies."	Breed mostly in mud at edges of streams and ponds. Development about two months; often longer.
GROUP C.—Usually smallish flies of the shape and general appearance of house-flies. Antennæ with two very short basal joints and a large third joint hanging down in front of the middle of the face and having a thin bristle-like process (the arista), bearing fine hairs, which points forwards. Proboscis short or long, always rather horny and polished in appearance. See figures for Group C	Several genera Family *Muscidæ*.*	"Flies."	Breed in dung or decaying refuse of all sorts. Development variable.
GROUP D.—Thorax flat, polished and horny. Head small, proboscis short and stout. Colour generally brownish, feet with strong claws: generally seen on cattle and dogs. Resting position as in figure of *Hippobosca*	Genus *Hippobosca* and others. Family *Hippoboscidæ*.	"Flat-flies," "Dog-flies." Cattle-flies."	Do not lay eggs, but deposit large, round "puparia" in dry sheltered places. From these the fly emerges in about a month. See figure of *Hippobosca*.
Order SIPHONAPTERA (Fleas). GROUP E.—Jumping wingless insects with body laterally compressed, breeding in dusty and dirty places.			
Order HEMIPTERA. GROUP F.—(1) Flattened creeping wingless insects, with proboscis folded back in a groove under the body.	Family *Cimicidæ*	"Bed-bugs."	Breed in sheltered crevices. The eggs hatch in about ten days, but complete development takes several months.
Order ANOPLURA. (2) Flattened creeping wingless insects, with proboscis quite short and not folded back ...	Family *Pediculidæ* and other.	"Lice."	Eggs often attached to hairs. The young are much like the adults.

The *Mallophaga* or bird-lice resemble *Anoplura*, but have jaws in place of a proboscis and generally a much broader head than the true lice. See figure *Mallophaga*. Ticks are blood-suckers, but are not really insects; the two chief groups of ticks are roughly indicated in the figure.

* See plate opposite.

On the second night of the Sessions a conversazione, which was largely attended by the members, was held in the Exhibition grounds between the hours of 7 and 11-30 P.M. The following series of Lantern Slide Demonstrations, were exhibited *viz*:—

7—7-20 p.m. ... Leprosy, Treatment by Nastin.
By Capt. BEAUCHAMP WILLIAMS, I.M.S., Bushire.

7-40—8 p.m. ... ... Choelra Epidemics.
By Major LEONARD ROGERS, I.M.S., Calcutta.

8-20—8-40 p.m. ... .Parasite of Dehli Boil.
By R. ROW, M.D. (LOND.), Bombay.

9—9-20 p.m. ... ...Blood-sucking Insects.
By F. M. HOWLETT, 2nd Imperial Entomologist, Pusa.

9-40—10 p.m. ... ... The Tsetse Fly.
By Capt. GREIG, I.M.S., Bombay.

10-20—10-40 p.m..Snakes, Poisonous and Non-poisonous.
By Major WALL, I.M.S., Almora.

11—11-20 p.m. ... ... Fevers.
By Major LEONARD ROGERS, I.M.S., Calcutta.

The Committee were "At Home" to the members throughout the evening and selections of music were performed at intervals by the Band of the 123rd Rifles, through the kind permission of Lieut.-Colonel Delamain and the Officers of that Regiment, under the direction of Mr. Fredilis, the Band Master.

On the 25th of February the Museum was closed, and on the 26th the Exhibition, popularized by the addition of numerous carefully selected side entertainments, was opened by His Excellency the Governor of Bombay, President of the Congress, to the general public.

OPENING CEREMONY.

The opening ceremony took place on the Exhibition grounds in the Oval in the presence of a large and representative gathering. The space near the temporary Bandstand was utilised for the purpose, the Bandstand serving as a platform for the accommodation of the promoters and organisers of the Congress and the Exhibition. His Excellency, who was accompanied by Miss Clarke, arrived punctually at six o'clock, when a guard of honour of 100 rank and file of the Gloucesters, who had taken up a position to the north of the platform under Major Tulloch, presented arms. After inspecting the guard, His Excellency proceeded to his seat on the platform.

ADDRESS OF WELCOME.

The Hon. Sir John Muir-Mackenzie, in opening the proceedings, said :—Your Excellency, Ladies and Gentlemen—As President of the Exhibition Section of the Bombay Medical Congress, the honour of opening these proceedings devolves upon me, and it gives me very great pleasure on behalf of the Committee to welcome Your Excellency and Miss Clarke with your guests to our Exhibition, and to thank you, ladies and gentlemen, for your presence here this evening. At the opening ceremony of the Sessions, not many days ago, Surgeon-General Stevenson described how the small nucleus of a committee appointed at Your Excellency's initiation became expanded into a widely representative body which further became split up into small working sub-committees. He further gave a brief sketch of the progress of the joint work of those sub-committees, which resulted in the production of the interesting programme which was concluded in sessions yesterday. I need only add that the work of organizing the Exhibition proceeded side by side with that of the Congress, the fixed aim of the Committee being to provide an exhibition whereby all visitors to the Congress could personally see specimens of all the very latest appliances in the domains of medicine, surgery and sanitation, the latest medical and scientific publications, microscopic and lantern slide preparations of pathogenic organisms and affected tissues in connection with tropical affections, and other demonstrations such as X-rays, extraction of snake venoms, different species of Indian rats, etc., etc. Having fixed upon their programme, the Committee decided at a very early stage to extend such of these advantages as might be generally appreciated to the public, and resolved that, on the close of the Congress sessions, the Exhibition should be bereft of its very strictly technical attributes, popularized by the addition of some specially selected side entertainments, and thrown open for some weeks to the general public.

This evening sees the realisation of their hopes. The large numbers of medical men who have come to Bombay from all parts of India, from Europe, Japan, Sumatra and the Philippines to participate in the Sessions have unanimously voted the Exhibition in all its characteristics as a unique feature in the history of medical conferences. The Pathological Section being of a strictly technical character has been closed, and the exhibition, popularized as mentioned above, is now offered to the general public for a time with a sincere wish that they will avail themselves of it and thus not only combine recreation and pastime with much that will be instructive, but also incidentally aid medical charities towards which all surplus balances will be eventually devoted.

The Exhibition buildings, all after the Indo-Saracenic style of architecture, have been erected under the kind supervision of Messrs. C.F. Stevens & Co., the honorary architects to the Exhibition, from designs gratuitously submitted by those gentlemen. Mr. Haji Ahmed Dewjee of the firm of Messrs. Ahmed Dewjee Brothers has completely furnished the Exhibition at his own charges; and, in addition, has gratuitously provided several thousands of foliage plants for the gardens and flags for the grounds. He has further undertaken to illuminate at his own cost the main entrance every night for so long as the Exhibition remains open. In his letter to the Committee Mr. Haji Ahmed Dewjee writes :—"I make this offer with the sincerest wish that the Con-

OPENING CEREMONY OF THE EXHIBITION.
The Hon'ble Sir John Muir-Mackenzie reading the opening address.

gress and Exhibition will be a great scientific and financial success, and beg that the outlay which the proposed works will entail will be accepted as my contribution to the Congress." The laying out of the gardens and the designs for decorating the grounds were undertaken by Mrs. W. E. Jennings, who has also for several months past given up much of her time in assisting in the secretarial work in which she has been most helpful to the Committee. The organization of the Pathological Section was undertaken by Captain J. Cunningham, I.M.S., of the Bacteriological Laboratory, Parel, who spared no time or pains to render it the great success which it has proved to be. Mr. Howlett, the Second Imperial Entomologist (Pusa, Bengal), very kindly came to Bombay at the end of January to assist in the preparation of specimens of disease-carrying insects, etc., and the help he rendered in this most important and delicate work was of the greatest value. Captain Lloyd of the Indian Museum also came down in advance of the sessions as the delegate of that institution with a valuable collection of exhibits showing the different species of rats in India.

The microscopes used were obtained on loan from private individuals and medical institutions in Bombay and other parts of India, and I take this opportunity of expressing on behalf of the Committee the deep debt of gratitude which we owe to those who have willingly lent their valuable microscopes at a great risk for the purpose. Mr. Charles W. White, representative in India of Messrs. Burgoyne Burbidges, was in England for several months in 1908, and kindly acted as the Committee's honorary agent while there for arranging with the different leading firms regarding exhibits, etc., etc. Mr. A. K. Pai, B.A, of the Bombay Municipal Health Department, the honorary assistant curator, has, with the kind permission of the Executive Health Officer, given up a considerable portion of his time, and practically all his leisure, for several months, to help the Committee in organizing the undertaking. His experience of other exhibitions has made his help most invaluable, and the Committee owe him a deep debt of gratitude for his untiring and unselfish efforts to make the Exhibition successful. Through the courtesy of the Executive Engineer, Presidency, Mr. Pherozeshaw Nasserwanji of the Public Works Department has been good enough to undertake the supervision of the grounds, enclosing walls and buildings and the restoration of the ground after the demolition of the buildings to its original condition. Mr. Framji Dubash of Girgaum has for several weeks been most helpful to the Committee in lending flowering and other plants and assisting in the arrangement of the side-show buildings.

Minimax and other fire extinguishers have been scattered in convenient places all over the Exhibition by Messrs. Marcks and Company and Messrs. Jost and Company. Demonstrations for instructing the Exhibition staff in the use of these appliances have been held, and it is hoped that, in the event of fire, visitors will use any of the appliances, if handy, or obtain extra ones from Messrs. Marcks' stand north of the main gate. In addition to such precautions, at the suggestion of Mr. Nichols, Chief Officer of the Municipal Fire Brigade, the Municipal Commissioner has kindly sanctioned a fine chemical engine and a manual engine being shown as exhibits, and, at the same time to be in readiness for use at a moment's notice. A special shed has been erected for these machines over a hydrant, and from this position a jet can be thrown on to any part of the Exhibition buildings almost instantaneously. Just south of the main entrance will be found the office of the general curator, the enquiry and left luggage offices, a telephone station, a postal pillar box and a temporary dispensary with resident medical officer and all necessary equipment for first-aid in the event of sudden illness or accident. Through the kindness of the Commissioner of Police a special temporary police force has been engaged and placed under the direct supervision of a resident inspector. The authorities of the leading railway companies have made liberal concessions to those coming from distances of over a hundred miles, and it is hoped that this will induce many to visit our show who would perhaps otherwise not be disposed to do so. To refer individually to all who have helped us in our undertaking would be impossible in the time at my disposal, but I take this opportunity of expressing our very grateful thanks to one and all for their help, and especially to the ruling chiefs and leading citizens who have contributed to our funds, many having given donations ranging from Rs. 100 to Rs. 1,000, and also to the public bodies which have liberally supported us,—the Bombay Municipal Corporation having given Rs. 10,000 and the Trustees of the Port Rs. 5,000. Our efforts have been all through powerfully stimulated by the very great interest taken by Your Excellency in the work, and by our assurance that your knowledge of the many difficulties which beset the organizers of such an undertaking will induce you to be indulgent towards any shortcomings. In once more thanking Your Excellency I request you on behalf of the Committee and members to accept this token of the Exhibition and formally declare it open to the public. (Applause).

A handsome silver key was then handed to His Excellency, who replied as follows :

THE GOVERNOR'S SPEECH.

Sir John Muir-Mackenzie, Ladies and Gentlemen—At the initial conference held at Government House, it was decided that with the Medical Congress should be associated an exhibition of a general character illustrating the latest appliances of Medical Science and indicating the progress of pathological research. I am sure that this was a wise decision, and that the Exhibition has served a very useful purpose. I was greatly struck by the pathological section, which reflects the utmost credit, upon Captain Cunningham. The arrangement of specimens left nothing to be desired, and no one could view the exhibits without gaining an insight into the importance of the research work now being carried on, and forming some idea of the enormous number of problems awaiting solution. We are also greatly indebted to Mr. Howlett, Captain Beauchamp Williams and Captain Lloyd for their valuable work and contributions.

From to-day, the Exhibition is to be shorn of its severely technical features and thrown open to the general public. Enough will be left, however, to provide useful general instruction. I hope that the visitors will not spend all their time in demonstrating the laws of gravity on the switchback railway; but that they will carry away and disseminate some useful knowledge of the laws of hygiene. From to-day the æsthetic aspects of the exhibition assume fresh importance, and we must congratulate the architects, Messrs. Stevens, & Co., on the excellent effect they have produced. Exhibitions are, I believe, almost invariably in a state of chaos for days or weeks after they are opened. It is very satisfactory to find that things are differently managed in Bombay, and that everything was in order last Monday.

For the arrangement of the decorations and the laying out of the grounds we are deeply indebted to Mrs. Jennings, who has devoted herself unsparingly to this important task. We have only to look around to see how successful she has been. Mr. Haji Ahmed Dewjee has shown great public spirit by furnishing the Exhibition and illuminating the main entrance, while his generous provision of foliage, plants, and flags has added greatly to the attractions of our little white city.

When a year ago I took the steps to initiate the many preparations necessary for the holding of such a Congress as this, I felt confident that we should achieve success. Now that the Congress is over, I can say that the success has been greater than I dared to hope. We have had generous help from many quarters, and we have drawn together a large assembly of earnest men and women, who will carry back to their work new inspirations and some fresh knowledge of the latest developments of medical science. We shall never be able to estimate in the form of figures the advantages which will result from our Congress, and the impetus which it will give to medical progress in India.

Movements of this kind—the movements which do most good to the world—can never be brought to the test of the accountant. It is of their essence that their influence should be gradual and silent in its operation. Modern impatience of quick results, which has to some extent infected the slow-moving East, tends towards hasty judgments and ill-considered actions from which real progress suffers. That is not the method of science, which demands the careful collection and analysis of facts before it takes a definite step in advance. I hope and I believe that from the valuable papers which have been read at this Congress, and from the useful discussions which have followed, good will ultimately accrue to the masses of India, who suffer far too much from preventible evils.

The success, which we can claim for our Congress, is due to a happy combination of conditions. We have had an excellent organization thoroughly thought out in advance, cordial co-operation from the Medical Profession in India as a whole, and the valuable help from the outside in the presence of eminent leaders of Medical Science from a distance, and in the papers contributed. Lastly the management of the actual business of the Congress by the Presidents of Sections, whom we owe a debt of gratitude, has been uniformly excellent.

I am sure that you will agree with me that special credit is due to Lieutenant-Colonel Jennings, who has marshalled all the forces at his disposal with the greatest skill and tact, and who has been the directing brain of the machine which has worked with such conspicuous power and smoothness. Apart from the actual organization of the Congress, it requires little imagination to realise how much thought and attention to detail were required to create this Exhibition in which nothing seems to have been omitted which could promote the instruction as well as the recreation of the visitors, and minister to their comfort and safety. The task has been greatly facilitated by the generous pecuniary assistance received from ruling chiefs, public bodies and citizens, which have enabled the general secretary to render the scope of the undertaking wider than was originally contemplated, and also by the sense of financial security due to the very liberal guarantee of Rs. 10,000 against any deficit which has been offered by a well-known philanthropist who wishes to be nameless in this connection. Our thanks are also due to Messrs. Pai, Pherozeshaw Nasserwanji, and Framji Dubash for valuable assistance in many directions.

I have now the pleasure to declare this Exhibition open to the general public which, I am sure, will appreciate the thoughtful care of Colonel Jennings, and will also, I hope, take full advantage of the opportunity of combining recreation with the acquisition, in some measure, of useful knowledge which cannot be too widely spread in India.

His Excellency then turned a lock with the silver key, which by an electrical connection caused the unfurling of the Union Jack, the Band, at the same time, playing "Rule Britannia."

PRESENTATION OF MEDALS.

Miss Clarke was then presented with a Congress Medal and a pretty bouquet of flowers by Mrs. Jennings, and gave away medals to the following ladyworkers:—Miss Benson, Miss Kelaokar, Mrs. Jennings, and Mrs. Haigh.

VOTE OF THANKS.

Surgeon General Sir Gerald Bomford, in moving a hearty vote of thanks to His Excellency for opening the Exhibition, said this was a most interesting Exhibition. He was sure it would be a great success and hoped people would contribute to that success by coming there and patronising the various shows. (Hear, hear.)

Dr. Temulji B. Nariman in seconding the proposition said the idea of holding the Medical Congress and Exhibition had originated with His Excellency the Governor and they owed him a deep debt of gratitude for the unabated interest he had taken in the scheme from the beginning to the end. The first Medical Congress in India was held at Calcuttta about fourteen years ago and then there was a talk of holding the second Congress in Bombay after three years. But during the interval plague overtook this beautiful city, and, though appeals were made by the public to hold such a Congress, the Government of the time found themselves unable to take an interest in the matter. It was owing to His Excel-

Presentation of Medals by Miss Clarke.

lency Sir George Clarke's sympathetic support that they were able that evening to see this grand Exhibition. In His Excellency they had an ideal Governor of commanding talents and wide experience, of which there could not be a better testimony than the learned and scholarly address delivered by him at the opening of the Congress. They sincerely hoped and trusted that the results of the Bombay Medical Congress and Exhibition would mark a notable advance in the crusade against Plague, Malaria and other tropical diseases which had been so ably discussed in the different sections of the Congress.

Sir Bhalchandra Krishna, in supporting the vote of thanks, said :—Ladies and Gentlemen,—I have great pleasure in supporting the resolution tendering our best thanks to H. E. the Governor, and I do so with the greater pleasure since I believe no vote of thanks was ever better deserved. From the inception of the idea of the Congress to its full organization and completion His Excellency's interest has been living and real, and it was the prestige of his association with the Congress that gained all the success, which it has achieved. The idea of a Medical Exhibition like that of the Congress itself originated with His Excellency and he has been unsparing in his endeavours to organize both in a superb style. The magic of his name attracted round him workers like Lieut.-Col. Jennings, and, inspired by his example and guidance, this band of workers has laboured night and day and has succeeded in bringing together these rich treasures of science and art. His Excellency seems to possess an abiding interest in popularising science, and his efforts are continuously directed to disseminate its blessings far and wide. Soon after His Excellency arrived in this country he was deeply touched at the ravages plague was making amongst us, and to mitigate the ravages he essayed to impress upon the people the benefits arising from inoculation. His Excellency called together a conference of Indian Journalists in the Presidency and invited them to see for themselves the operations at the Parel Laboratory and spread correct knowledge among the people as to the preparation of the prophylactic fluid. His Excellency also invited medical officers in Native States to view the working of the Laboratory, and it was in the address to these medical gentlemen that His Excellency first suggested the idea of holding a Medical Congress in Bombay.

On examining the educational problem in this Presidency His Excellency noticed that science did not receive the attention it deserved. He prominently mentioned the need of encouraging the study of science and providing for its instruction in this Presidency in the Convocation address last year, and his appeal drew forth three munificent endowments in the cause of science. The invitation and organization of the Medical Congress and Exhibition is a further development of His Excellency's endeavours in the cause of the promotion of science.

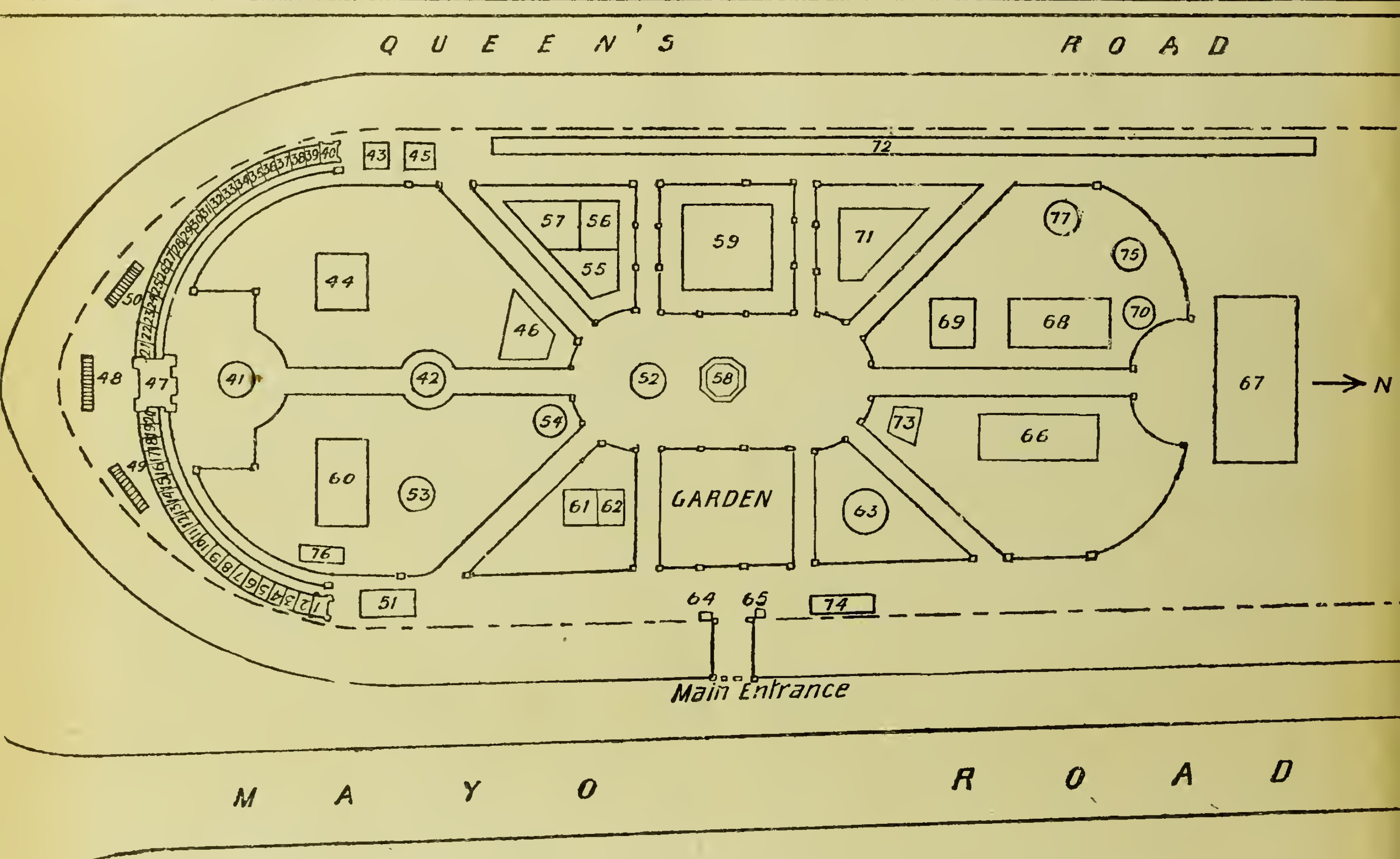
The Medical Congress has long been a cherished dream with some of us here, but it was the genius of H. E. Sir George Clarke which has realised that dream. As I have said on another occasion, I fully realise the onerous and arduous character of an organization like the Congress. I know it cannot be easily repeated, but I fervently hope this will not be the last of its kind. In Europe such scientific Congresses and Conferences are established institutions and are held at stated periods. In India too, there are Congresses and Conferences held every year for the discussion of political, social, educational and other subjects. There is no reason why a Medical Congress should not likewise be held, and under such sympathetic guidance as that of His Excellency, we may well cherish the hope that the idea will not be a vain dream. With these brief words let me commend to you the vote of thanks to His Excellency and ask you to carry it by acclamation.

Dr. Rajabali Patel in further supporting the proposition said that during the short time His Excellency had been amongst them he had endeared himself to every sect and community and had won the admiration of all who had had the good fortune to come in contact with him. He felt confident that he was only voicing the feelings of all present there when he said that His Excellency's Governorship would constitute a landmark in the history of this country for the great good he had already done and which they knew he would continue to do. (Applause.)

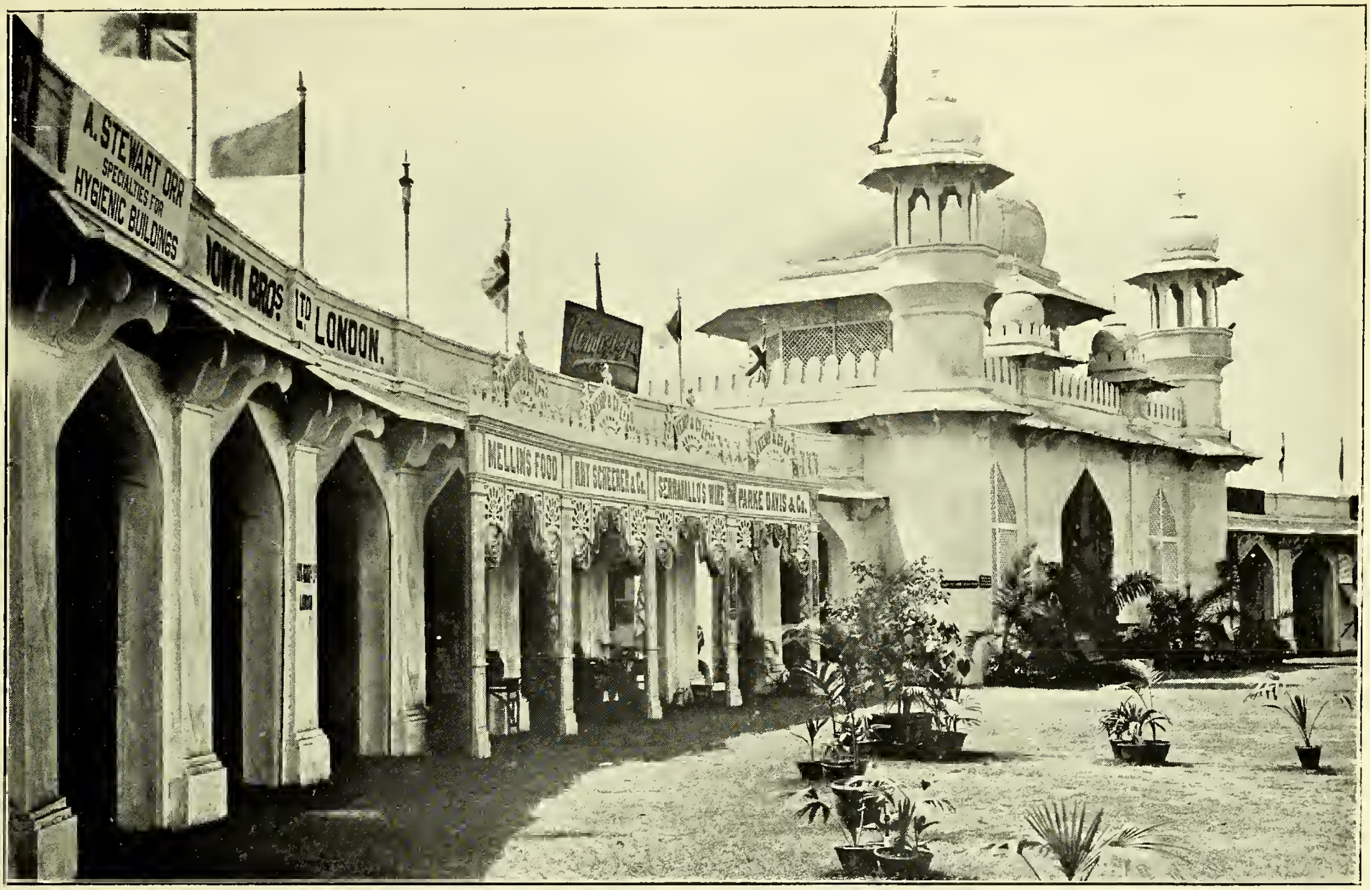
His Excellency and Miss Clarke then made a tour of inspection of the Exhibition.

Programmes and Guide-books were provided for visitors to the Exhibition. To both were appended the descriptive chart of the Exhibition reproduced here in order to furnish a ready guide to all parts of the Exhibition, and, in the latter, detailed lists of the exhibits were given. The main Exhibition Building consisted of a semi-circular sweep of stands skirting the southern end of the enclosure, with a Central Hall for the Bombay Municipal Health Exhibition. North of this were detached buildings comprising the exhibits of Messrs. Tothill Sharp & Co., Messrs. Marsland, Price & Co., Messrs. Richardson Cruddas & Co., The Holborn Surgical Instrument Co., Horlick's Malted Milk Co., The Bombay and London Tobacco Company, Messrs. Macbeth Bros. & Co., Messrs. Jost & Co., The Virol Co., The Bombay Improvement Trust, and a Model Operation Theatre by Messrs. Powell & Co. The stands in the Main Building were taken by Messrs. Arnold & Sons, Messrs. Southall Bros., Messrs. Maw Son & Sons, The Alembic Chemical Laboratory, Messrs. Oppenheimer & Co., Messrs. Thomson & Taylor, Messrs. Sissons & Co., Messrs. Down Bros., Messrs. Kemp & Co., Messrs. Parke Davis & Co., Mr. E. Merck, Messrs. Garlick & Co., Messrs. Treacher & Co., Messrs. Lawrence & Mayo, Messrs. Thomas Black & Co., Messrs. Bertie Smith & Co., The International Correspondence Schools, Messrs. Thacker & Co., Messrs. Grimault & Co., Messrs. William Cooper & Nephews, Messrs. Whiteaway, Laidlaw & Co., Messrs. Paranjpe Athalye & Co. Messrs. N. Powell & Co., and Messrs. Burroughs Welcome & Co. South of the Main Building were suitably arranged retiring rooms for all classes, and near the entrance gate were the Offices of the General Secretary, The Assistant Curator, The Resident Medical Officer, The Enquiry and Lost Luggage Offices and a Telephone Station.

Descriptive Plan of Exhibition and Shows.



No.	
1-4	Arnold & Sons.
5-6	Southall Bros. & Berkeley.
7-8	James Wright & Co.
9-10	Alembic Chemical Laboratory.
11-12	Oppenheimer & Co.
13	Thomson & Taylor.
14	Sissons & Co. (Mr. A. S. Orr.)
15-16	Down Bros.
17-20	Kemp & Co.
21-22	E. Merck.
23-25	Garlick & Co.
26-27	Treacher & Co.
28	Lawrence & Mayo.
29	Thos. Black & Co.
30	Bertie Smith & Co.
31	International Corres. Schools.
32	Thacker & Co.
33	Grimault & Co.
34	William Cooper & Nephews.
35	Whiteaway, Laidlaw & Co.
36	Paranjpe Athalye & Co.
37-39	N. Powell & Co.
40	Burroughs&Wellcome.
41	Tothill Sharp & Co.
42	Holborn Surg. Instrument Co.
43	Maisland, Price & Co.
44	Model Operation Theatre (N. Powell & Co).
45	MacBeth Bros. & Co.
46	Richardson & Cruddas.
47	Municipal Health Dept. Exhibit.
48	Latrines.
49	Ladies' Retiring & Cloak Room.
50	Gentlemen's Retiring & Cloak Room.
51	Offices of Secretary & Resident Medical Officer, and Telephone Enquiry & Left Luggage Offices.
52	Bombay & London Tobacco Co.
53	Five-Inch Equatorial Telescope.
54	Maltine Manufacturing Co.
55	Jost Fan Company.
56	Allen & Hanbury.
57	Virol Company.
58	Bandstand.
59	Refreshment Room (Cornaglia & Co.).
60	Bombay Impt. Trust Exhibits.
61	Siemens Bros.
62	Burgoyne & Burbidges.
63	Maze.
64-65	Ticket Offices.
66	Bandmann's Egyptian Theatre.
67	Excelsior Cinemotograph.
68	Panorama.
69	Laughing Gallery.
70	Fish Pond.
71	Refreshment Rooms (Haridas Valji & Co.)
72	Switch Back Railway.
73	Anatomical Curiosities.
74	Minimax Fire Extinguishers and Roneo Duplicators.
75	Optical Delusions.
76	Municipal Motor Fire Engine.
77	Fairy Bower.



Central Hall in which the Bombay Municipal Health Department Exhibition was held.

Bird's-eye View of the Exhibition.

NATURE OF EXHIBITS.

Stands 1 to 4.—*Messrs. Arnold & Sons, London.*
Surgical Instruments and Appliances, Hospital and Operation Room Furniture and High Pressure Steam Sterilizers.

Stands 5 & 6.—*Messrs. Southall Brothers and Berkeley, Birmingham.*
Drugs, Galenicals, Surgical Dressings and Sanitary Specialities.

Stands 7 & 8.—*Messrs. Maw, Son & Sons, London.*
Surgical Instruments and Appliances, Aseptic Hospital Furniture, Crouch's Microscopes and Optical Apparatus.

Stands 9 & 10.—*The Alembic Chemical Works, Bombay and Baroda.*
Drugs, Chemicals, Essences, Perfumery and Disinfectants.

Stands 11 & 12.—*Messrs. Oppenheimer, Son & Co.*
Preparations of Pharmaceutical Drugs, The Anglo-American Pharmaceutical Co.'s Appliances, Messrs. Cress and Owen's Glyco-Thymoline and Anti-sera from the Pasteur Institute of Paris.

Stand 13.—*Messrs. Thomson & Taylor, Bombay.*
Izal Disinfectant.

Stand 14.—*Messrs. Sissons & Co.*
Modern Constructional Engineering Specialities for hygienic and fire-proof buildings including reinforced concrete, asbestos sheets, glass tiles, distemper, limmer asphalte and expanded metal.

Stands 15 & 16.—*Messrs. Down Brothers, London.*
Surgical Instruments and Appliances of all kinds and Hospital and Operation Room Furniture.

Stands 17 to 20.—*Messrs. Kemp & Co., Bombay.*
Glycolites (Galenicals manufactured without alcohol), practical demonstrations of tabloid manufacture, Mellin's Food, Serravallo's Tonic, Scientific Apparatus (*by Gallenkamp*), Surgical Instruments (*by Kny Scheerer*), Analytical Apparatus (*Roborat Co.*), Microscopes (*Watson's*) and Drugs, Sera, Vaccines, Soaps and Toilet Preparations (*Parke Davis & Co*).

Stands 21 and 22.—*E. Merck, Darmstadt.*
Pharmaceutical Drugs and Analytical Re-agents.

Stands 23 to 25.—*Messrs. Garlick & Co., Bombay.*
Building materials (including tiles, rib and expanded metal, reinforced concrete and drainage pipes), model lavatories, sinks, baths, geysers, basins, urinals, water-closets, &c., &c.

Stands 26 and 27.—*Messrs. Treacher & Co., Bombay.*
Pharmaceutical Specialities, Soluble Essences, Surgical Dressings, Instruments, Hospital Furniture, Filters, Chemical and Scientific Apparatus, Miol and Collis Brown's Chlorodyne.

Stand 8.—*Messrs. Lawrence & Mayo, Bombay.*
Astronomical, Mathematical, Surveying, Drawing and Optical Instruments.

Stand 29.—*Messrs. Thomas Black & Co.*
Porcelainware, Hospital Furniture and Fittings, Sanitary Appliances, Climax Filters and model sinks, baths, &c.

Stand 30.—*Messrs. Bertie Smith & Co.*
Odol, Pasteur-Mallie Filters, and Carbonic Acid Gas.

Stand 31.—*The International Correspondence Schools.*
(Agent, A. Wise, Esq., Taj Building, Wallace Street, Fort, Bombay.)
Prospectus and Pamphlets of Special Electro-Therapeutic Course (including Gynæcology, Genito Urinary, Surgical Neurological, Eye, Ear, Nose and Throat, Rœntgen Rays, Nurses' and Dental Courses).

Stand 32.—*Messrs. Thacker & Co., Bombay.*
Medical Publications.

Stand 33.—*Messrs. Grimault & Co.*
Special Pharmaceutical Preparations (including Cypridol, Apioline, Dusart's Syrup, Peptone Wine, Cerevitine, Zomol, &c., &c.)

Stand 34.—*Messrs. William Cooper & Nephews, Berkhampstead.*
Cooper's Fluid Disinfectant, Milk Oil Fluid, Lavene Vesol, Amorosa, Carbolic Powder, Coal Tar Soap, Shofa and Cattle Hair Clippers.

Stand 35.—*Messrs. Whiteaway, Laidlaw & Co., Bombay.*
Tanton's Bedsteads for Hospitals, Air Pillows, Impregnated Pillows, Thermos Flasks and Rubber Hot Water Bottles.

Stand 36.—*Messrs. Paranjapye Athalye & Co., Bombay.*
Veterinary Instruments and Books, Veterinary Antitoxines and other remedies, the National Dairy Company's Butter.

Stands 37 to 39.—*Messrs. N. Powell & Co., Bombay.*
Chemical and Scientific Apparatus (*Messrs. Townson & Mercer*), Surgical Instruments (*Messrs. Weiss & Son*), Elastic Hosiery (*E. Sallis*), Antiseptic Dressings (*Messrs. Johnson & Johnson*), Dental Appliances (*Messrs. Claudius Ash & Sons*), and their own Medical, Surgical and Veterinary Appliances.

Stand 40.—*Messrs. Burroughs, Wellcome & Co., London.*
Chemicals and Galenicals, Tabloid Equipments (Pocket, Saddle, Cycle, Carriage and Motor Cases), Dressings, Serums and Vaccines, Antidote (Water Analysis Bacteriological) and Urine Test Cases, &c., &c.

Stand 41.—*Messrs. Tothill Sharp & Co., Bombay.*
Preparations of Nestle's Milk, Zeal's Thermometers, Pearson's Disinfectants and the Sanitas Company's Disinfectants.

Stand 42.—*The Holborn Surgical Instrument Co.*
Surgical Instruments of all kinds and Sterilizing Apparatus.

Stand 43.—*Messrs. Marsland & Price, Bombay.*
Sanitary Appliances (including W. C. pans, flushing cisterns, waste preventer taps, Wolff's dilutor, latrines and hospital fittings), Building Materials (including tiles, reinforced concrete, expanded metal, asbestos sheets, &c.), model chawls, plague huts and mono-rail tramway.

Stand 44.—*Messrs. Powell & Co., Bombay.*
Model Operation Theatre fully fitted up on the latest principles.

Stand 45.—*Messrs. Macbeth Brothers & Co., Bombay.*
Velox Portable Steam Coil Disinfector, F. P. Airlight.

Stand 46.—*Messrs. Richardson & Cruddas, Bombay.*
Doulton baths, lavatories and w.-closets, bathroom fittings and accessories, drain cleansing apparatus, models of miscellaneous sanitary fittings, sinks, geysers, &c., &c.

Stand 47.—*Bombay Municipal Health Exhibition.*—

Exhibits.

1. Model of the Island of Bombay.
2. Model of Tansa Water Works.
3. Model of Milch-cattle Stables.
4. Model of Stables.
5. Model of Privies 2 (Dr. Ahmed Mirza of Hyderabad).
6. Model of Choola (Rao Bahadur Talcherkar).
7. Model of Chawls.
8. Model of House Connections (open and covered) and Privy.
9. Model of Dwellings in Mysore.
10. Model of House for calculating cubic contents (24 pieces).
11. Section of Jones' Manhole (Brass).
12. Gully Trap.
13. Street Gully with clearing arm.
14. Gully with 18″ open channel.
15. 2 Yard Gullies.
16. Yard Gully with connection for rain water.
17. 8 Interceptors.
18. Trap.
19. U Trap.
20. Washdown Closet Pan.
21. Washdown Closet Trap.
22. Compound Washdown W.-C. and Trap.
23. Valve Closet Basin.
24. Washdown W.-C.
25. Washdown Lead Trap.
26. Lavatory Basin.
27. Access Pipe.
28. Galvanized Drain Plug.
29. Cast Iron Access Pipe Connection, ½ inch.
30. 3 Casy Bends.
31. 2 Y Junctions.
32. 2 Model Drain Pipes.
33. Half Channel Pipe.
34. Half Channel Bend.
35. Bag and Tube.
36. Home and Gymnastic Machines, Back Bone, Pulling, Rowing and Riding Machines.
37. Developers :—
Dawood's, Sandow's, Ferry's, Whitty's and others.
38. Strength Testing Machines :—
Grip, Lungs, Punching, Weight-lifting, Weight-teller with Height, Measuring Rod, Tug of War.
39. Models of Incinerators (Horsfall Destructor Co.).
40. Rat Traps. (Wholesale Co-operative Society of India, Bombay.)
41. Glass Filters from Messrs. S. M. Dey & Co., Engineers, Calcutta.
42. The Model of a Public Urinal.
43. Viruses.—
(1) Mouse Septicæmia, (2) Swine Erysepalas, (3) Danysz Virus, (4) Liverpool Virus, (5) Raticide, (6) Ratite, (7) Pasteur Virus, (8) Ratin No. 1, and (9) Ratin No. 2.
44. Chemical Poisons.—
(1) Arsenic, (2) Barium Carbonate, (3) Quick Lime, (4) Cork fried in Ghee, (5) Mercuric Cyanide, (6) Potassium Cyanide, and (7) Strychnia Hydrochloras.
45. Phosphorus Poisons.—
(1) Common Sense, (2) Mushicide, (3) Laboratory Rat Exterminator and (4) New Laboratory Rat Exterminator.
46. Mosquito Larvæ in Water.
47. Fish in Water which eat Mosquito Larvæ.
48. New Horse Ambulance.

Stand 47 (*a*) (Corner of Central Hall).—*Messrs. Meister Lucius & Bruning.*
Prophylactic and Antitoxic Sera of all kinds.

Stand 47 (*b*) (Corner of Central Hall).—*St. John's Ambulance Association, Bombay Centre.*
New Equipoise Bed-stead, and samples of all materials and literature used in connection with First Aid, Home Nursing and Shield Competition courses.

Stand 47 (*c*) (South of Central Hall).—*Mrs. Remy, Matron, Bai Motlibai Hospital.*
The Remy Infants' Crib capable of attachment to any ordinary bed-stead and of being folded away under the bed when not in use.

Stand 47 (*d*) (South of Central Hall).—*Mr. J. Wallace, Bombay.*
The Wallace Anemometer for measuring very delicate currents of air.

Stand 52.—*The Bombay and London Tobacco Company.*
Pasquali, Pera, and Engelhardt's Cigarettes.

Stand 53.—*Messrs. Lawrence & Mayo, Bombay.*
Five-inch Equatorial Telescope, open to all visitors for a trial at a small fee. (Proceeds kindly given to Medical charities.)

Stand 54.—*The Maltine Manufacturing Co., London.*
Maltine Preparations, Liquid Peptonoids, Beef Peptonoids and Soluble Foods.

Stand 55.—*Jost Fans Supply and Engineering Co., Bombay.*
Jost's Radio Fans, Electric Fans, Fire Extinguishers and General Engineering Appliances.

Stand 56.—*Messrs. Allen & Hanbury's Limited, London.*
Surgical Instruments and Appliances and High Pressure Steam Sterilizers.

Stand 56 (*a*)—*Mr. Nowrojee Pestonjee Pavri, Bombay.*
Electrical Apparatus.

Stand 57.—*The Virol Company.*
Virol.

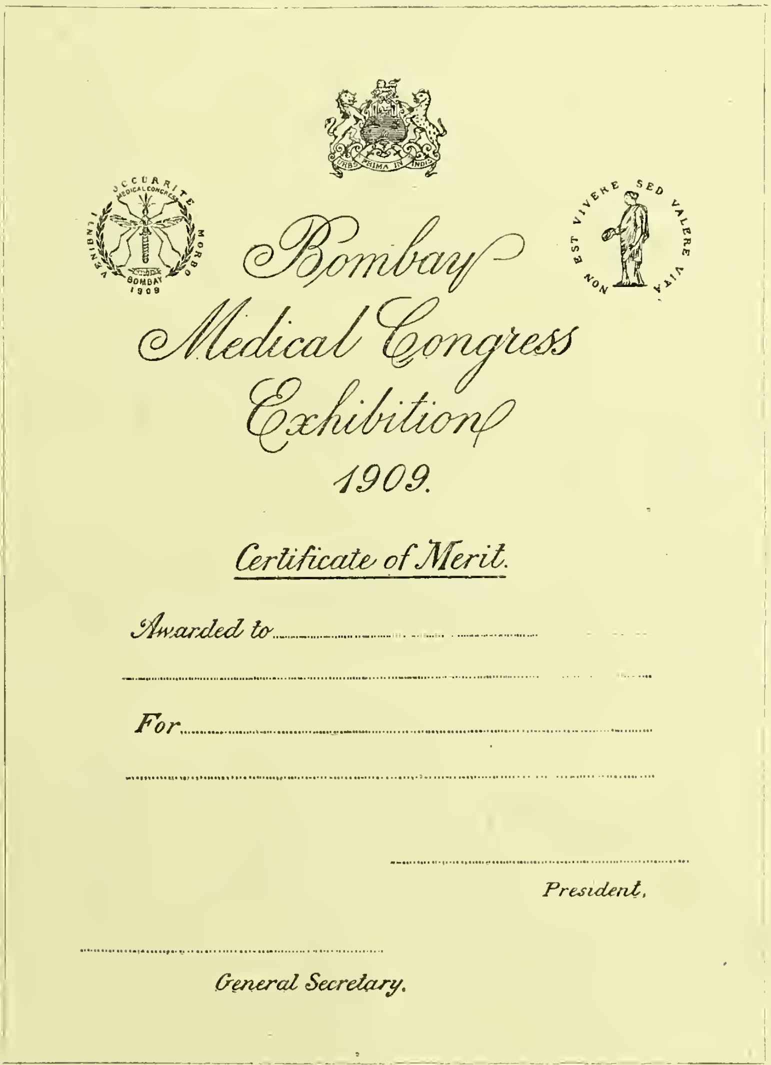
Stand 60.—*Bombay Improvement Trust.*
Model Chawls and models of insanitary and improved areas in Bombay.

Stand 61.—*Messrs. Siemens Brothers, London.*
Electrical Appliances and Plant for developing X rays, &c.

Stand 62.—*Messrs. Burgoyne Burbidges & Co., London.*
Samples of Pharmaceutical Products and Office of Mr. Charles W. White, Agent for the East.

Stand 74.—*Messrs. Marcks & Co., Bombay.*
Minimax Fire Extinguishers and Roneo Duplicators.

N.B.—Messrs. Marcks & Co. scattered Minimax Fire Extinguishers all over the Exhibition and held demonstrations for instructing the staff in the use of these appliances. Visitors were requested, in case of fire, to use any of the appliances, if handy, or to obtain extra ones from the stand which was just north of the Main Entrance.


Bombay Medical Congress Exhibition

1909.

Certificate of Merit.

Awarded to ....

....

For ....

....

....

President.

....

General Secretary.

Certificates of Merit were awarded by the Committee to Exhibitors in the design here reproduced, each being signed by the President and General Secretary of the Congress.

Appendix I.

MEMBERS OF THE BOMBAY MEDICAL CONGRESS.

His Excellency The Governor of Bombay .... President.

A

Abbott, Capt. S. H. L., I.M.S., Punjab.
Achaya, Dr. H. M., Bilka.
Achyuta Rao, Hospital Assistant P. S., Bangalore.
Adhyaru, Dr. S. G., Bombay.
Adie Lt.-Col. J. R., I.M.S., Punjab.
Advani, Dr. B. G., Karachi.
Advani, Dr. P. H., Hyderabad, Sind.
Ahmed Dewjee, Khan Saheb Hajee, Bombay.
Ainsworth, Major H., I.M.S., Punjab.
Ajaibsing Hospital Assistant, Dharamshala, Punjab.
Ali, Dr. Farhat, Saitabad, Hyderabad (Deccan).
Allarakhiabhai Kanjee, Esq., Bombay.
Allen, Dr. B. J. Baroda Camp, Gujarat.
Allison, Capt. A. A., I.S.M.D., E. B. and Assam.
Anant Rao, Asst. Surgn. D. G. Poona.
Anderson, Lt.-Col. J., I.M.S., U. P.
Anderson, Capt. J. I.M.S. Bombay.
Anderson. Capt. S., I. M. S., E. B. and Assam.
Anderson Capt. W.M., I.M.S., Rajputana.
Anglo-American Pharmaceutical Co., Ltd., England.
Anjaria Dr. R G., Mangrol, Kathiawar.
Anklesaria, Dr. B. K. Poona.
Anklesaria Dr. D. E. Ahmedabad.
Anklesaria, Dr. H. N., Bombay.
Anklesaria, Dr M. D. E., Ahmedabad.
Anklesaria Dr M. T., Bombay.
Ansari Hakim Mahomed Karim, Bombay.
Ansari, Hakim Mazhar Karim, Bombay.
Antia, Dr. M. J., Bombay.
Armstrong Asst. Surgn. R. G., R. I. M. S. "Hardinge".
Arnim Lt.-Col. H. C. L., I.M.S., Bombay.
Atal, Capt. P. P., I.M.S. Madras
Atarchand, Rai Saheb, Ludhiana Punjab.
Atkins, Dr. T. E. Sylhet Bengal.
Austrian Lloyd's Steam Navigation Company the Agent, Bombay.
Avari, Hospital Assistant C. R., Bombay.
Aylen, Capt. E. V., R.A.M.C., Bombay.

B

Babington, Capt. J. W. H., I. M. S., Tientsin.
Bachoobai Rustomjee, Dr. (Miss), Bombay.
Bahadurji Mrs. D. N., Bombay.
Bahadurji Dr. J N., Bombay
Bahadurji. Dr. (Miss) Piroja Bombay.
Baird, Capt R. F., I.M.S., U. P.
Baker, Capt. M, I.M.S., Burma.
Bakhle, Major C. R. I.M.S., Bombay.
Bakshi, Dr R. R., Rajkote.
Balabhai Maganlal Dr. Baroda.
Balasinor State. The Raja of Balasinor.
Balchand Oogarchand Esq. Bombay.
Balfour, Dr. (Miss) M., Patiala, Punjab.
Balpodivala Dr. B., Bombay.
Balsara Asst. Surgn. P. P., Aden.
Bamber, Lt. Col. C. J., I.M.S., Punjab.
Banatvala Lt.-Col. H. E., I.M.S., C. P.
Banerji, Asst. Surgeon G. C., Farukhabad, U. P.
Banker, Dr. S. A. Bombay.
Bannerman, Lt-Col. W. B., I.M.S., Bombay.
Bardi, Dr. D. R., Bombay.
Baria Dr. D. H., Dhrangadhra.
Barry Lt.-Col. J. P., I.M.S., Bombay.
Bate, Lt.-Col. T. E. L., I.M.S., Punjab.
Batha, D. P., Esq., Bombay.
Batliboi Dr. H. B. Bombay.
Batlivala Dr. H. L. Bombay.
Batlivala, Dr. S. S., Bombay.
Baumler, Miss, Calcutta.
Bawa, Dr. H. F., F.R.C.S.E., Ceylon.
Beals, Dr. L. H., Wai, Satara.
Beals Dr. R. F., Wai. Satara.
Beevor, Lt.-Col. W. C., R.A.M.C., Punjab.
Behramji Dr. D. B., Jetpur.
Behrawalla, Dr. C. T. Ahmedabad.
Beit, Capt. F. V. O., I.M.S. Burma.
Benjamin Dr. J., Ahmedabad.
Bennett, Major H. I.M.S., Bombay.
Bennett, Major V. B., I.M.S., Bombay.
Bensley, Lt.-Col. C. N., I.M.S., U. P.
Benson, Miss A. M. Bombay.
Benson, Surgn.-Genl. P. H., I.M.S., Madras.
Bentley, Dr. C. A., M.D., D.P.H., Mateli, Dooars.
Berkeley-Hill, Lt. O. A. R., I.M.S., Hyderabad Deccan.
Berry, Major A. E., I.M.S., C. P.
Betts, Capt. A. J. V., I.M.S., Bombay.
Bezonji Dosabhai Dr. Bombay.
Bhadbade, Dr. S. G., Miraj.
Bhandari, Senr. Asst. Surgn. Kidarnath, Amritsar.
Bhan ari Dr. P. G., Bombay.
Bharucha Dr D. N., Bombay.
Bharucha, Asst. Surgn. E., Poona.
Bharucha, Dr. M. K., Bombay.
Bharucha Dr. R P. Bombay.
Bhaskar Narayan, Hospl. Asst., Umbergaon Thana.
Bhathena, Lt. S. J., I.M.S., Bombay.
Bhatt, Dr. M. A. Radhanpur State.
Bhatwadekar, Dr. Sir Bhalchandra Krishna Kt., Bombay.
Bhatwadekar, Dr. M. H, Dadar, Bombay.
Bhichta Dr. S., Erinpura Rajputana.
Bhimji Shamji & Co., Messrs., Bombay.
Bhopal Sing, Dr., Cawnpore.
Bhoparadikar, Asst. Surgn G. G., Bassein.
Bidie, Major G., I.M.S., Bombay.
Billimoria, A. J., Esq., Bombay.
Billimoria, Dr. E D., Bombay.
Billimoria, Dr. R. B., Bombay.
Birdwood, Major G T, I.M.S., U. P.
Bishop, Dr J. H., Dharwar.
Bisni, Dr. F. N., Bombay.
Bisset, Capt. E., I.M.S., Punjab.
Black, J., Esq., Bombay.
Blackmore, Dr. G. J., M.D., Bombay.
Blackwell, Lt.-Col. C.T., R.A.M.C., Bombay.
Bocarro, Dr. J. E., L.M. & S. Broach.
Bolton, Capt. H., I.M.S., N.-W. F. Province.
Bombay Medical Union Bombay.
Bomanji Edalji Cashmath, Esq., Bombay.
Bomford, Surgn.-Genl. Sir Gerald, I.M.S., Simla.
Bonesetter, M. D. B., Esq., Bombay.
Bonus, A. C., Esq., I.C.S., Satara, Bombay.
Bose, Dr. C. C, Saidpur, Rangpur.
Bose, Rai Bahadur C. L., Ranchi.
Bose Capt. S, I.M.S., Madras.
Boyce, Dr. C. P., Belgaum.
Boyd, Capt. J. F., I.M.S. Punjab.
Bradbury, J. F. Esq., Bombay
Braddon Dr. W. L., M.B., B.S., F.R.C.S., England.
Bradley, Dr. (Miss) G., Bombay.
Brassey, Capt. L. P., I.M.S., Burma.
Brierley, Capt. C. I., I.M.S., Baluchistan.
Brijlal Javerilal Dr. Bombay.
British Medical Association, The Bombay Branch of the, Bombay.
Britto, Dr. A., Bombay.
Britto Dr. J. A. Bassi.
Broacha Dr. S. B., Bombay.
Brown Lt.-Col. E. H., I.M.S., Calcutta.
Brown Major W., R.A.M C. Poona.
Brunton Sir Lauder, Bart. M D., England.
Bryson Major R., I.M.S, Madras.
Buchanan Lt.-Col A., I.M.S. C. P.
Buchanan Lt.-Col. W. J, I.M.S., Editor, "Indian Medical Gazette," Calcutta.
Buist, Major A. W. T. I.M.S., Punjab.
Burch, A. R., Esq, Bombay.
Burden Major H., I.M.S. Nepal.
Burjorji Behramji, Dr., Bhavnagar.
Burke, Lt. Col. W. H., I.M.S., Bombay.
Burnett, Major S. H., I.M.S., Bombay.

C

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I

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Science, The Indian Institute of, Bangalore.
Scott, Lt. H. B, I M S., Madras.
Scott, Capt. L. B., I.M.S., E.B. & Assam.
Scott, Asst. Surgn. L. G., Bombay.
Scott-Moncrieff, W. D., Esq., C.E., England.
Scott-Moncrieff, Major W. E., I.M.S., N.-W F. P.
Scroggie, Dr. W. R., South Sylhet.
Scroggie, Capt. W. R. J., I.M.S., Madras.
Scudder, Dr. (Miss) J. S., Vellore.
Seervai, Dr. H. A., Bombay.
Seervai, Dr. R. F., Bombay.
Seethaputty, Asst. Surgn. T., Saidapet, Madras.
Selby, Major W., I. M. S., U. P.
Semple, Lt.-Col. D., R. A. M. C. (Retired), Kasauli.
Sen, Dr H., Dinajpur, Patna, Bengal.
Sethna, Dr. D. C., Bombay.
Sethna, Dr. M. K., Bombay.
Sett, Jalbhoy A., Esq., Bombay.
Settna, Dr. S. R., Bombay.
Sewell, Lt. R. B. S., I. M. S., Punjab.
Seymore, Capt. C. J., I. M. S., Chelsea.
Shah, Asst. Surgn. N. G., Thana.
Sharman, Dr. I. P., Peshawar.
Shaw, Capt. W. S. J., I. M. S., Burma.
Sheppard, W. D., Esq., Bombay.
Sherren, Lt. H. G., R.A.M.C., Bombay.
Shettle, Capt. F. B., I.M.S., Punjab.
Shega Prof. K., Japan.
Shikare, Asst. Surgn. P. V., Poona.
Shirazi, Mirza Mahomed, Esq., Bombay.
Shivdas Parmanandas, Dr., Bombay.
Shore, Lt.-Col. R., I. M. S., Bombay.
Shroff, Dr. B. S., L. M. & S., Bombay.
Shroff, Dr. K B., Bombay.
Shroff, K R, Esq., Bombay
Sidick, Mahomed Hajee Sabboo, Esq., Bombay
Simson, Lt. N. S., I. M. S., Bengal.
Simson, Lt. W. J., I. M S., Hyderabad, Deccan.
Singh, Major B. J., I. M. S., Burma.
Skinner, Lt. J. M., I. M. S., C. I.
Sloggett, Surgn.-Genl. A. T., C. M. G., Bombay
Smales, Capt. W. C., R.A.M.C., Bombay.
Smallman, Capt. A. B., R.A.M.C., Bombay.
Smith, Dr. A., Bombay.
Smith, Miss C. M., Dadar, Bombay.
Smith, Dr. L. G., Pithapuram.
Smith Major F. A I. M. S., C. I.
Smith, Lt. F. S., I. M. S, E. B. & Assam.
Smith, Major H., I. M. S., E. B. & Assam.
Smith, Major H. A, I. M. S., U. P.
Smith, Major J. B. I. M. S., Bombay.
Smith, Major S. Browing, I. M. S., Punjab.
Smyth, Lt.-Col. J., I. M. S., Mysore State.
Sobhani, Haji Mahamed Haji Esmail, Esq., Bombay
Sodhi Capt. N. S., I. M. S., U. P.
Soloman, Dr. J., Ahmedabad.
Soltan, Miss E., Nagpur, C. P.
Somji, Dr. S. R., Bombay.
Sommerville, Dr. J., Jodhpur, Rajputana.
Sorabji, Mrs. Bachoobai M., Bombay.
Sorabji Dadabhoy, Dr. Bombay.
Sousa Dr. A., Ahmedabad.
Southon, Capt. E. C., I. M S., Punjab.
Spencer, Dr. J. B., Bombay.
Staley Miss M. E., Lahore.
Standage, Major R. F., I. M. S., Madras.
Standard Oil Company, The Manager, Bombay.
Steel, Major E. B., R.A.M.C., C. I.
Steel, Capt. R. F., I. M. S., C. I.
Steen, Capt. H. B., I. M. S. Calcutta.
Steen Capt. R., I. M. S., U. P
Steinhoff, Asst. Surgn. F. G., Bombay.
Stephen, Capt. L. P., I. M. S., Bombay.

Stephenson, Dr. (Miss) E., Ahmednagar.
Stevens, C. F., Esq., Bombay.
Stevens, Major C. R., I. M. S., Calcutta.
Stevenson, Surgn.-Genl. H. W., I.M.S., Bombay.
Stevenson, Lt. W., I. M. S., Bombay.
Stewart, Lt. A. D., I. M. S., U. P.
Stewart, Capt. G. F., I. M. S., Quetta.
Stewart, Capt. G. H., I. M. S., Bombay.
Stillwell, Dr. E., Bankipur, Patna.
Stokes, Capt. T. G. M., I. M. S., C. P.
Stokes, Dr. W., Switzerland.
Stone, Major C. F., R.A.M.C., Madras.
Street, Major A., I.M.S., Bombay.
Strickland, Lt.-Col. P. C. H., I.M.S., Burma.
Subhayya, Dr. P. V., Guntur, Madras.
Sukhadwalla, Damodardas G., Esq., Bombay.
Sukhia, Dr. J. C., Bombay.
Sukhia, Dr. N. H. E., Bombay.
Sulemani, Khan Bahadur Dr. S. J., Baroda.
Sullivan, Col. W. O., A. M. S., C. I.
Sunth, The Raja of, Sunth.
Surveyor, Dr. D. M., Bombay.
Surveyor, Dr. N. F., M.D., D.P.H., Bombay.
Sutherland, Major D. W., I. M. S., Punjab.
Sutta, Dr. C. N., Bombay.
Sweetham, Major S. W., R.A.M.C., Bombay.
Sykes, Lt.-Col. J., I. M. S., U. P.
Sykes, Lt.-Col. W. A., I. M.S., Quetta.
Symons, Major T. H., I. M. S., Madras.

T

Talati, Dr. H. P., Nadiad.
Tambe, Dr. G. R., Indore.
Tarachand, Dr. J. M., Bombay.
Tarapore, Lt. P. K., I.M.S., Hyderabad, Deccan.
Tata, D. J., Esq., Bombay.
Tata, Dr. D. R., Bombay.
Taylor, Capt. E. C., I.M.S., Punjab.
Taylor, Lt. J., I.M.S., N.-W. F. P.
Telang, Asst. Surgn. R. H., Godhra.
Tengshe, Dr. V. S., Kolhapur.
Thadani, Asst. Surgn. M. G., Hyderabad, Sind.
Thakersey, Sir Vithaldas D., and Mr. Hemraj P. Bombay.
Thakkar, Dr. K. V., Bombay.
Thakor, Dr. M. J., Bombay.
Thomre, Dr. A. S. Malkapur, Buldana.
Thomson, Lt. W. M., I.M.S., Port Blair.
Thorburn, Lt. H. H., I.M.S., Malakand.
Thornley, Capt. M. H., I.M.S., Bengal.
Thresh, Dr. J. C., M.D., D. SC., England.
Thurston, Capt. E. O., I.M.S., Bengal.
Tiware, Dr. S. N., Bareilly.

Trades Association, The Bombay Presidency, Bombay.
Treasuriwalla, Dr. E. J., Bombay.
Trevor, Surgn.-Genl. F. W., C.B., M.B., V H.S., Simla.
Trewby, Dr. L., Amraoti.
Trilokekar, Dr. V. S., Bombay.
Tucker, Capt. E. F. G., I.M.S., Bombay.
Tucker, Capt. W. H., I.M.S., Madras.
Tudor-Owen, W. C., Esq., I.C.S., Palitana.
Tukaram Laxmon, Hospl. Asst. Kirkee.
Tuke, Capt. A. W., I.M.S., Bombay.
Turkhud, Dr. D. A., M.B., C.M., Satara.
Turkhud, Dr. V. A., Bombay.
Turner, Dr. J. A., M.B., D.P.H., Bombay.
Turner, Major R. G., I.M.S., U. P.
Tyebbhai Salebhoy, Dr., Bombay.
Tyndale, Capt. W. F., R.A.M.C., U. P.
Tyrell, Capt. J. R. J., I.M.S., N.-W. F. P.

U

Umachigi, Dr. V. S., Dharwar.
Unna, Prof. P. G., Germany.

V

Vacha, Dr. R. K., Bombay.
Vaidya, Dr. J. H., Bhuj, Cutch.
Vaidya, Rao Bahadur N. T., Bombay.
Vaidya, Asst. Surgn. S. K., Mirpurkhas, Sind.
Vakil, F. A., Esq. Bombay.
Vakil, Dr. J. R. Bombay.
Vakil, Khan Bahadur R. J., Ahmedabad.
Varis, Dr. S. M., M. D., Lucknow.
Vasavda, Dr. D. M. Poona.
Vatve, Dr. G. G., Bombay.
Velankar, Dr. T. D., Bombay.
Velankar, Prof. N. G., Bombay.
Velkar, Dr. A. V., Bombay.
Velkar, Dr. S. A. Bombay.
Venice Steam Navigation Co., The Agent, Bombay.
Venis, Dr. H. C., Bandra Thana.
Vijaykar, Dr. V. A., Bombay.
Vijaysinghji Kumar Shri of Palitana.
Vijbhukandas Atmaram Esq., Bombay.
Vishalgad, The Chief of, Vishalgad.
Vissanji Khimji Esq., Bombay.
Vissanji Tricumji Esq., Bombay.
Von Noorden, Prof. Carl (Wien), Germany.
Vorah, Dr. G. R., Bhavnagar.
Vorah, Dr. J. V., Bombay.
Vrajlal Bhagwandas Esq., Bombay.
Vyas, Hospital Asst. S. K., Ahmedabad.

W

Wachmuth, Dr. M., Sumatra.
Wadhwani, Dr. T. J., Hyderabad, Sind.
Wadia, Dr. D. R., Bombay.

Wadia, Asst. Surgn. J. P., Poona.
Wadia, N. P., Esq., Bombay.
Waikar, Dr. D. ., Kurundwad (Junior).
Wall, Major F., I. M. S., U. P.
Walton, Major H. J., I. M. S., U. P.
Wanless, Dr. W. J., M. D., Miraj.
Waters, Major E. E., I. M. S., Bengal.
Watson, Major T. E., I. M. S., Madras.
Watts, Capt. H., I. M. S., Punjab.
Watts, Dr. V. L., Bankura, Bengal.
Weir, Col. P. A., I. M. S., C. P.
Wells, Capt. N. S., I. M. S., U. P.
Wells, Capt. R. T., I. M. S., Punjab.
Wernicke, Lt. F. P., I. M. S., Punjab.
Whitamore, Capt. V. N., I. M. S., Burma.
Whitmore, Capt. E. R., U. S. Army, Philippines.
Whitcombe, Major E. G. R., I. M. S., Bombay.
White, Charles W., Esq., Bombay.
White, Capt. F. N., I. M. S., Punjab.
White, Capt. M. F., I. M. S., Bushire.
Wickham, Dr. (Miss) C. M., Rajkote.
Wildman, Miss R. R. C., Poona.
Wilkie, Col. D., I. M. S. E. B. & Assam.
Wilkinson, Major E., I. M. S., Punjab.
Willcocks, Capt. R. D., I. M. S., Madras.
Williams, Capt. ., I. M. S., Bushire.
Williams, Major C. E., I. M. S., Burma.
Williams, G. B., Esq., Calcutta.
Williams, Asst. Surgn. J. G., Bombay.
Williams, Capt. T. S. B., I. M. S., Bushire.
Williams, Lt. W. E. R., I. M. S., Bombay.
Williams, Lt. W. P. G., I. M. S., Punjab.
Williamson, Dr. J. R., Poona.
Willis, Col. C. F., I. M. S., C. I.
Willmore, Capt. W. S., I. M. S., U. P.
Wilson, Dr. A. S., Bombay.
Wilson, Lt.-Col. G., R.A.M.C., Punjab.
Wilson, J. Esq. C. S. I., I.C.S., Simla.
Wilson, Major R. P., I. M. S., Bengal.
Wimberley, Major C. N. C., I. M. S., Punjab.
Windross, Capt. M., I. S. M. D. Bhandara, C. P.
Winter, Major H. E., R. A. M. C., Bombay.
Wise, A. W., Esq., Bombay.
Wood, Major H. S., I.M.S., E.B. & Assam.
Wright, Major E. H., I. M. S., Madras.
Wright, Capt. W. ., I. M. S., U. P.

Y

Younan, Lt.-Col. A. C., I.M.S., Rawal Pindi.
Young, Capt. A. W. C., I.M.S., C. P.
Young, Capt. G., I.M.S. Hyderabad, Deccan.
Young, Major W., I. M. S., U. P.

Z

Zerwick, Rev. Dr. N., Gadag.

Appendix II.

OFFICIAL REPORT OF PROFESSOR MUSGRAVE, DELEGATE, PHILIPPINE ISLANDS.

31*st March* 1909.

To THE DIRECTOR,
BUREAU OF SCIENCE,
Manila, P. I.

Sir,

In compliance with the enclosed order, I have the honor to report as follows :—

I left Manila January 16th and arrived at Bombay February 19th ; left Bombay March 3rd and arrived at Manila March 23rd.

THE CONGRESS.

In scope. material presented and in attendance. this was surely the most successful Congress dealing entirely with the problems of tropical medicine which has ever been held. The conception of the Congress as well as a large part of its very great success was due to the President, H E Sir George Clarke, Governor of Bombay. The very complete and satisfactory organization and successful programme was largely due to the efficiency and zeal of the General Secretary Col. W. E. Jennings, who was ably assisted by Mrs Jennings.

The scope of the Congress was very comprehensive, embracing practically the entire field of tropical medicine and sanitation. The opening exercises were held in Convocation Hall of the University of Bombay and were presided over by H E. the Governor. This session was more or less general and the large hall was packed with members of the Congress and their friends The opening address was delivered by the President of the Congress, who gave a most excellent review of the history of modern medicine. Surgeon-General Stevenson gave a history of the organization of the Congress and Surgeon-General Sloggett proposed a vote of thanks to H E. the Governor for his interest and aid, without which the Congress could not have been a success. The distribution of appropriate silver medals to the foreign delegates by H. E. the Governor concluded the opening ceremonies.

SCIENTIFIC SESSIONS.

The scientific sessions were divided into six sections and were all well attended and what is more important, most of the papers presented aroused considerable discussion.

A list of the papers presented at the Congress is shown in the programme, a copy of which is enclosed. Obviously, it is impossible here to note more than a few of the most important points brought out in the discussions.

Cholera.—Major Rogers emphasized the advantages of the intravenous injection of hypertonic salt solution in the treatment of this disease, and the general tenor of the discussion of his paper was strongly confirmatory of his observations.

Variola.—The discussion strongly favored the preservation of vaccine lymph in lanolin as having decided advantages over the more usual method of preservation in glycerin. The collapsible screw-capped tube is largely used in India as containers for vaccine and through the courtesy of Surgeon-General Benson your delegate was furnished several sample tubes of this type filled with lanolinated vaccine as furnished by the Government Institute at Madras.

The Dysenteries did not receive the amount of discussion which their importance in tropical medicine demands. Appendicostomy as a method of treatment in intractable cases was rather strongly endorsed and the reported observations were more strongly favorable to it than our results in Manila would warrant. Amœbic infections of the colon apparently are not so common in India as they are in the Philippine Islands.

Typhoid Fever.—The strong points brought out in this discussion were those showing the advantages to be derived from antityphoid vaccination both in decreasing the incidence of the disease and in mitigating its type in those who become infected after vaccination.

Malaria was quite fully discussed from the standpoint of prevention as well as its relation to black water fever. Major R. Ross of Liverpool was present and led the discussion relating to practical measure for the eradication of the disease from infected localities. Many interesting points were brought out concerning the best methods of determining the incidence of the disease and the value of various sanitary methods. Major Ross called the attention of the Congress particularly to the value of the "Spleen Index" in children as a most valuable guide in determining the prevalence of malaria. This method was used extensively by Ross in his Campaign against malaria in Mauritius.

Plague is a particularly important subject in India and was fully discussed. Prof. Kitasato's paper was largely confirmatory of the previous reports of the Indian Commission's claims that rat fleas are the principal transmitting agents of the disease. There was no question raised as to the value of anti-plague inoculations, the interested and experienced members of the Congress apparently accepting the advantages of such inoculations as a proved fact, and they should be employed where possible. Considerable difference of opinion existed regarding the best general measures applicable for the eradication of plague from infected localities. However, the use of antiseptics as generally employed was almost unanimously condemned as being a useless expense.

Leishman-Donovan bodies and similar parasites received considerable attention without showing any very great gain in our knowledge regarding the subject during the past year. Dr. Row, of Bombay, exhibited cultures and preparations from an organism of Oriental sore, showing several stages including a flagellate stage.

Beriberi received considerable attention. Braddon furnished a strong paper in support of his well-known hypothesis of white rice transmission of the disease, and I have since seen the advance sheets of a similar report from Dr Frazer of the Kuala Lumpar laboratory which contains the strongest evidence yet brought forward in support of this hypothesis.

Leprosy.—The papers and discussion of this subject were mostly devoted to considering the virtues of the Nastin treatment of the disease. One paper was decidedly favorable, but another was equally positive that the treatment is in no sense specific.

Mycetoma was the subject of three papers including that of your delegate.

Section four of the Congress was devoted largely to a consideration of general public health measures and section five was the surgical section. Neither of these were attended by me.

Section six was the pathologic exhibit and it was remarkably complete and well managed. There were 200 microscopes in use and hundreds of museum specimens and drawings of interesting tropical conditions.

One of the very instructive features of the Congress was the evening spent in listening to a series of popular lectures with lantern slide demonstrations upon important subjects.

Social Features.

The social side of the Congress was very pleasant and the various functions took up practically all the spare time of the delegates.

I was a guest at Government House during the week of the Congress and wish to take this occasion to express my thanks and appreciation of the many courtesies shown me by H. E. Sir George Clarke, Governor of Bombay, and to the several members of his staff for the many pleasant hours spent with them.

The scientific portion of the Congress was followed by a kind of carnival which was to last several weeks and the funds raised in this manner are in part to be used in defraying the expenses of the Congress.

Impressions of the Trip.

In a ten weeks' trip through the heart of the Far East, one must receive many impressions about many things; some of them good, more bad, and all to be taken for what they are worth and not to be regarded as established facts. My itinerary was briefly as follows: Hongkong, Singapore, Penang, Rangoon, Calcutta, across India, Bombay, and Colombo. In making this trip I travelled on five ships representing four different steamship lines and had a fair experience with Indian railways, and the total distance travelled was about 10,000 miles. Observations of use here are those pertinent to citizens of the Philippine Islands and all conclusions consciously or unconsciously are reached by comparison with conditions in our own country.

Travel.—The route travelled is a particularly interesting one, but I cannot conceive of any one ever wanting to make it a second time. The steamship accommodations are good, the railroads are fairly comfortable, but passengers must furnish their own bedding and the hotels are exceedingly poor as a rule. The subsistence service to passengers on railways in India is the worst and poorest managed that I have ever seen. Thousands of tourists passing through India annually have resulted in building up a "tipping" system which for the uninitiated traveller is as bad as it possibly could be. The things to see are of two classes: the old historic landmarks and the modern results of England's stewardship. Both are wonderful.

Tourists pass through India by the thousands annually and the money spent by them must reach an enormous figure. This enormous tourist trade is largely the result of advertising; of course, there is much to advertise, but the advertising is very extensively and well done. It is not all paid for locally, for India has many arteries for disseminating information, such as the steamship companies, the railroads, the tourist agencies and many other large business concerns which have become financially interested and depend upon the tourist trade for a considerable portion of their income. The actual sights are in many ways not so interesting as those of the Philippines. For example, there is one "waterfall" in Burma which is extensively advertised and visited annually by thousands of visitors which does not begin to compare in beauty or picturesqueness with the one near Los Banos, to say nothing of those in Pagsanjan. I talked personally with more than 1 0 American tourists making long visits to the Orient and found but five of this number who had included Manila in their itineraries. Inquiry as to the reason for this brought out a number of reasons, but in more than 75 per cent. one or more of the following were given:—

1. Lack of information.—Large numbers of people think there is nothing of interest to see and there are no methods of enlightening them.

2. Poor transportation.—It is surprising how current the idea is that Manila can only be reached by small boats which encounter typhoons during almost every voyage.

3. Bad hotels.—This idea is very general and to a great degree unjustly so. I have heard dozens of people give this as one reason for not coming to Manila, when at the same time they were stopping at, and apparently satisfied with, a hotel poorer in every respect than any hotel in Manila.

4. Unhealthfulness.—The idea of the unhealthfulness of Manila is an extremely prevalent one and some of the stories told about it are simply amazing to one who knows the actual conditions. For example, I was assured by one party (and they showed a prominent States' paper for the authority) that there was at that time a big epidemic of typhoid at Manila. At that very time the city we were in was having ten to twenty cases a day, but of this they knew nothing.

On another occasion, and in a city closer home, a party was afraid to come because of cholera when on that same day there were actually 22 cases in the city where they were staying.

Several other minor points, such as climate, are occasionally given as reasons for not coming to Manila, but the above, and particularly 2 and 4, are the principal

ones. In thinking over these things the conclusion seems obvious that the principal difference between the Philippine Islands and other countries which have so many tourists is that: *We advertise our troubles to the world and don't advertise our attractions sufficiently, while the other countries advertise their attractions extensively and keep their troubles to themselves.*

Services.—The British Colonial services appear to have advantages over ours—advantages which it seems to me are for the benefit of both the Government and the employee. These advantages relate to hours of duty, leave privileges, salary and, most important of all, to the maintenance of a retirement plan for long service and to other conditions which make the Indian service attractive as a *career.*

The daily hours of duty for Government officials and employees are considerably shorter in India than they are in the Philippine Islands. This standard of short hours has been reached by experience. It is not, as explained to me by a prominent Government official, any special concession to the employee, but it has been found actually to increase the efficiency of the service to such an extent as to prove economical from the standpoint of Government.

I am sure that medical men are practically unanimous in the opinion that Government office hours in the Philippine Islands are too long and not most advantageously chosen, and that the extra effort thereby called out is one of the principal causes of frequent changes in personnel.

In India salaries and leave privileges are both more liberal for the same class of work than they are in our service. By far the most important advantage of the British Colonial service over ours is found in the retirement and pension system of the former. Under it the Colonial service is made a career and the expense of training and importing new men is used in pensioning old employees who have made the personnel of the service smaller and more efficient by giving to it their years of experience.

The sanitary problems of India are somewhat similar to our own. The diseases encountered are similar and there are even worse conditions of mixed population, natural filthiness, ignorance and tribal or caste prejudices to be met.

A great deal has been and is being accomplished, particularly about the larger centres of European population, but in large areas of dense native population progress is very slow and advancement made largely in spite of the people themselves. In many places visited by me the general conditions are simply appalling,—so bad that one wonders how any of the people remain alive.

Of the parasitic diseases, Malaria seems to be one of the most important and is now being dealt with along broad lines in several places.

Plague claims its hundreds of thousands of victims annually and its suppression under existing conditions is a problem of too much magnitude for any government without the thorough co-operation of the populace. Amœbic infections do not appear to be nearly so frequent as with us, due in part, no doubt, to the occurrence of a season of cold weather in the country. Even water and other so-called saprophytic types of amœbæ appear to be fewer than with us. On the other hand, several other forms of animal parasites are more frequently encountered and some, particularly the Leishman-Donovan parasites which are very prevalent in certain parts of India, have not been found in the Philippine Islands.

Research medicine is well represented in the British services in India and most successful work is being done along original lines.

The idea of temporary exchanges of duties between research workers and teachers in the Philippine and the Indian services was discussed with several of the authorities and I believe such arrangements could be carried out without much difficulty if it were thought to be advisable.

In conclusion, I wish to again express my gratitude for the very kindly manner in which I was received and entertained while in India.

Very respectfully,
(Sd.) W. E. MUSGRAVE.

OFFICE OF THE GOVERNOR-GENERAL
OF THE PHILIPPINE ISLANDS,
MANILA, 29*th December* 1908.

Sir,

You are hereby designated as Official Delegate from the Philippine Islands to the Bombay Medical Congress to be held at Bombay, India, during the month of February, 1909, and directed to proceed to Bombay, India, at such time as will enable you to be present at the opening of said Medical Congress.

Your travelling expenses in going to, and returning from, Bombay and your actual and necessary expenses during your stay in Bombay will be a proper charge against the appropriation for the Bureau of Science.

Very respectfully,
(Sd.) JAMES F. SMITH,
Governor-General.

Dr. W. E. MUSGRAVE,
Assistant Chief, Biological Laboratory, Bureau of Scie ce, Professor of Clinical Medicine, Philippine Medical School, Manila.

Appendix III.

Bombay Medical Congress Balance Sheet showing State of Funds on 1st June 1909 and approximate State on 22nd June 1909.

STATEMENT A.

Receipts.

	Rs.	a.	p.
Subscriptions and Donations	51,283	3	0
Gate Money. Programmes &c.	13 784	1	0
Rent from Exhibitors and for Side Shows	7 375	6	0
Interest on Investments	790	9	10
Advertisements	3,831	0	0
From Exhibitors for Extra Lighting	386	0	0
Sale of Sheds &c.	3,024	7	6
Sale of Medals	718	10	0
Realization of Investments	22,497	10	11
	1,03,691	0	3

Disbursements.

	Rs.	a.	p.
Miscellaneous (General)	2,224	12	10
Advertisements	1,820	0	0
Establishment	310	4	0
Conveyance	406	0	0
Circulation of Proofs	1,367	0	10
Conversazione	1,159	12	0
Exhibition Grounds	1,271	5	0
" " Wages (including Police)	3,367	1	10
" " Miscellaneous	8,010	7	6
" " Lighting	7,820	13	6
" " Buildings and Insurance	22,271	8	0
Pathological Section	3,181	0	0
Transactions	2,500	0	0
Travelling and Out-of-Pocket Expenses	9,330	11	8
Rent and Rates (Office)	406	0	0
Medal	1,577	7	0
Bands	2,614	4	0
Fixed Deposit	10,000	0	0
Purchase of Stock*	23,482	14	6
Cash Balance	569	9	7
	1,03,691	0	3

* Securities of Rs. 11,500 still in hand (*vide* Statement **B**).

STATEMENT B.

Assets on 22nd June 1909.

	Rs.	a.	p.
Cash Balance as per Statement **A**	569	9	7
Received since 1st June	458	0	0
Due from Sundry Sources (probably Bad Debts), about	50	0	0
Securities in hand plus Interest due, about	11,500	0	0
	12,577	9	7

Liabilities on 22nd June 1909.

	Rs.	a.	p.
Transactions (about 150 extra Copies at Rs. 6-10-8 each plus Packing & Postage) about	1,200	0	0
Miscellaneous (Printing, Postages, &c., &c.), about	100	0	0
Balance, about	11,277	9	7
	12,577	9	7

Audited and found correct.

(Sd.) BHALCHANDRA KRISHNA, Kt.

(Sd.) HERBERT E. WINTER, Major, R.A.M.C.

22nd June 1909.

W. E. JENNINGS, M.D., D.P.H.,

Lieut.-Colonel, I.M.S.,

General Secretary, Bombay Medical Congress.

N.B.—The proceeds were converted into the nucleus of a Fund to be known as the "Miss Clarke Memorial Nursing Fund (founded by the Bombay Medical Congress)" which will be held in Trust by the Bombay Branch of the Countess of Dufferin's Fund, the revenue being administered by them for furthering the aims of nursing in the Bombay Presidency Proper.

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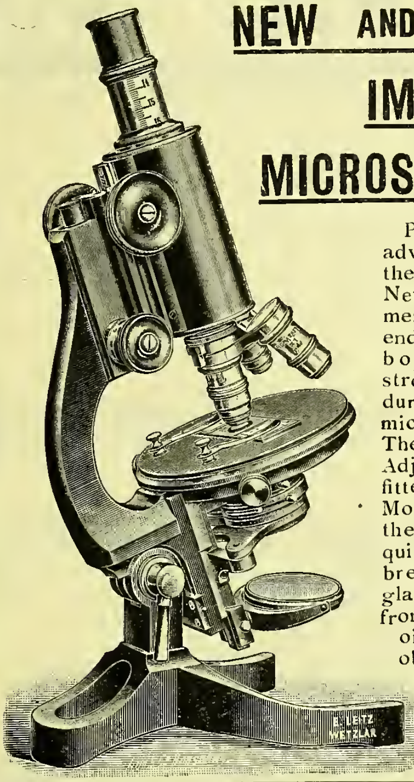

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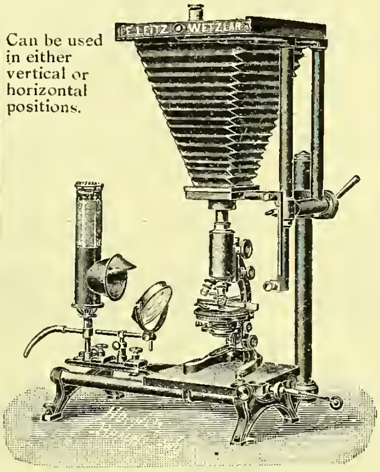

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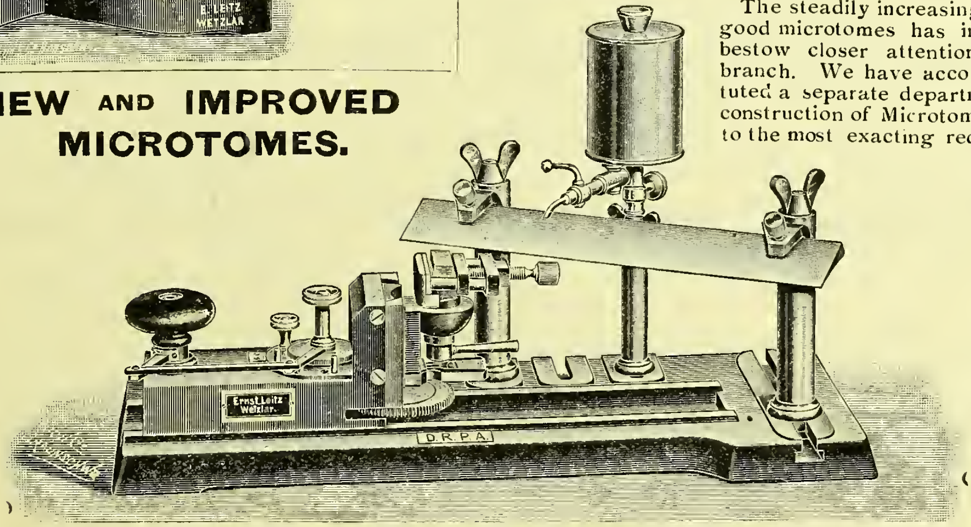

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